

The effects of different post-exercise recovery techniques on the subscales of the Recovery-Stress Questionnaire in university-level rugby players

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“Trust in the Lord with all your heart and lean not on your own understanding; in all your ways acknowledge Him, and He will make your paths straight”

Proverbs 3:5-6

Declaration

This dissertation serves as fulfilment of the requirements for the degree Magister Artium in Sport Science at the Potchefstroom Campus of the North-West University. The co-authors of the two articles that form part of this dissertation, namely Prof. Ankebé Kruger (supervisor and co-author) and Prof. Ben Coetzee (co-supervisor and co-author), hereby give permission to the candidate, Ms. Nicola Tinkler, to include the two articles as part of a master's dissertation. The contribution (advisory and supportive) of these two co-authors was kept within reasonable limits, thereby enabling the candidate to submit this dissertation for examination purposes.

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Summary

The effects of different post-exercise recovery techniques on the subscales of the Recovery-Stress Questionnaire in university-level rugby players

The physiological and psychological demands of rugby highlight the need for recovery strategies in the training programs of rugby players. Currently, passive recovery (PAR), cold water immersion (CWI) and contrast water therapy (CWT) seem to be the most popular recovery techniques used by athletes. Despite a growing interest in and benefits of these techniques, most studies only focus on the physiological benefits and often ignore the psychological benefits of these techniques. The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) is an instrument that allows researchers to assess potentially stressful and restful events, as well as the subjective consequences of these events on both the physiological and psychological responses of athletes. However, up until now no researchers have investigated these responses by making use of the RESTQ-Sport. Consequently, the objectives of this study were firstly to determine differences in the 48-hour post-recovery effects between PAR and CWI on the subscales (General Stress, General Recovery, Sport-Specific Stress and Sport-Specific Recovery) of the RESTQ-Sport in university-level rugby players, and secondly to determine differences in the 48-hour post-recovery effects between PAR and CWT on the subscales of the RESTQ-Sport in university-level rugby players.

Twenty-three u/21 university-level rugby players (age: 20.1 ± 0.4 years) voluntarily participated in this study. Players were randomly divided into a control (PAR) and an experimental group (CWI or CWT). All players were otherwise subjected to exactly the same testing procedures. Players completed the demographic and general information questionnaire as well as the RESTQ-Sport in the morning followed by baseline measurements after which players were allowed to eat breakfast. They again reported to the laboratory in groups of four players each after breakfast. Players were then subjected to a high-intensity fitness session of 15 minutes (intervention). Exactly three minutes after the fitness session ended, blood lactate measurements were taken, followed by execution of a 20 minute recovery session. For the purpose of the first objective the experimental group completed 20 minutes of CWI, whereas the control group

recovered passively for the same time period. For the purpose of the second objective, the experimental group completed 20 minutes of CWT, whereas the control group recovered passively for the same time period. The RESTQ-Sport was filled in again on the morning of the third day (post-recovery), 48 hours after the first completion of the RESTQ-Sport.

The analyses of intra- and inter-group differences for players who were subjected to PAR or CWI revealed statistically ($p < 0.05$) and practically significant ($d \sim 0.5$) decreases in conflicts/pressure and success from pre-fitness to post-PAR time periods. Being in shape and self-regulation were the only sport-specific stress and recovery activity-related subscales that indicated statistically ($p < 0.05$) and practically significant ($d \sim 0.5$) decreases over the same time period. Social recovery, general well-being, injury, self-efficacy, sport-specific stress and recovery revealed practically significant decreases ($d \geq 0.3$), while, general stress and physical recovery revealed practically significant ($d \geq 0.3$) increases. The experimental group experienced statistically ($p < 0.05$) and practically significant ($d \sim 0.5$) decreases from pre-fitness to post-recovery for success, general, social and physical recovery, whereas injury, being in shape, self-efficacy, self-regulation, sport-specific stress and recovery all revealed statistically ($p < 0.05$) and large practically significant ($d \sim 0.5$) decreases. General stress, social stress, disturbed breaks and personal accomplishment all showed practically significant ($d \sim 0.3$) decreases over the same time period. Despite these pre-fitness to post-recovery changes, the normal and Quade's ranks analysis of covariance (ANCOVA) revealed that only sport-specific recovery and self-efficacy showed a more pronounced significant decrease ($p < 0.05$) in the CWI- compared to the PAR-group.

Results with regard to intra- and inter-group differences for players who were subjected to PAR or CWT revealed the following: For PAR social stress, physical complaints, disturbed breaks and being in shape were the only RESTQ-Sport subscales that experienced statistically ($p < 0.05$) and medium practically significant ($d \geq 0.3$) decreases from pre-fitness to post-recovery. General and sport-specific recovery as well as self-efficacy ($d \sim 0.3$) all showed practically significant decreases over the same time period. The lack of energy subscale showed a statistically ($p < 0.05$) and large practically significant ($d \sim 0.5$) increase from pre-fitness to post-recovery. For the experimental group, a statistically ($p < 0.05$) and medium practically significant ($d \sim 0.3$) increase was observed for emotional stress, whereas self-efficacy revealed a statistically ($p < 0.05$) and medium practically significant ($d \sim 0.4$) increase from pre-fitness to post-recovery

time periods. Physical complaints and success both revealed practically significant ($d \sim 0.3$) decreases over the same time period. Despite all these intra-group changes, the normal ANCOVA revealed that self-efficacy as well as sport-specific stress and recovery were significantly ($p < 0.05$) more positively affected by CWT compared to PAR whereas PAR was more effective in causing positive changes in emotional stress and success compared to CWT over the 48-hour period.

Therefore, study results suggest that CWI and CWT, when compared to PAR, were more beneficial in enhancing 48-h RESTQ-Sport responses in a group of rugby players. Despite this conclusion, only a minority of RESTQ-Sport subscales revealed significant better recovery responses in CWI- and CWT- compared to PAR-groups. These results are contrary to previous findings which showed that CWI and CWT led to much better recovery responses than PAR. Nevertheless, it must be realised that even subtle, individual, post-recovery changes in RESTQ-Sport subscales after high-intensity exercise may have a positive impact on a player's performances. However, a more in-depth evaluation of players' psychological states is required to determine which recovery techniques are the most beneficial for individual player's recovery.

Keywords: cold water immersion, contrast water therapy, passive recovery, psychological recovery, Recovery-Stress Questionnaire, rugby

Opsomming

Die effek van verskillende postoefening-hersteltegnieke op die subskale van die Recovery-Stress Questionnaire in universiteitsvlak-rugbyspelers

Die fisiologiese en psigologiese eise van rugby beklemtoon die noodsaaklikheid van herstelstrategieë in die oefenprogramme van rugbyspelers. Tans blyk dit dat passiewe herstel (PH), kouewater-onderdompeling (KWO) en kontras-waterterapie (KWT) die mees gewilde hersteltegnieke is wat gebruik word deur atlete. Ten spyte van 'n groeiende belangstelling in en voordele van hierdie hersteltegnieke, fokus die meeste studies op die fisiologiese voordele en ignoreer die psigologiese voordele van hierdie tegnieke. Die Recovery-Stress Questionnaire vir atlete (*RESTQ-Sport*) is 'n instrument wat navorsers toelaat om die potensiele stresvolle en rustige gebeure, sowel as die subjektiewe gevolge van hierdie gebeure op beide die fisiologiese en psigologiese response van atlete te evalueer. Alhoewel, tot nou toe het geen navorsers hierdie response ondersoek deur gebruik te maak van die *RESTQ-Sport* nie. Dus, die doelwitte van hierdie studie was eerstens, om die verskil te bepaal tussen die 48-uur postherstelteffekte van PH en KWO op die subskale (Algemene Stres, Algemene Herstel, Sport-spesifieke Stres en Sport-spesifieke Herstel) van die *RESTQ-Sport* in universiteitsvlak-rugbyspelers, en tweedens om die verskil te bepaal tussen die 48-uur postherstelgevolge van PH en KWT op die subskale van die *RESTQ-Sport* in universiteitsvlak-rugbyspelers.

Drie-en-twintig onder/21 universiteitsvlak-rugbyspelers (ouderdom 20.1 ± 0.4 jare) het vrywillig aan hierdie studie deelgeneem. Die spelers is ewekansig verdeel in 'n kontrole- (PH) en 'n eksperimentele groep (KWO of KWT). Alle spelers is blootgestel aan presies dieselfde toetsprosedures. Spelers het die demografiese en algemene inligtingsvraelys asook die *RESTQ-Sport* in die oggend voor hul ontbyt geëet het, ingevul (pre-fiksheid). Nadat die basislynmetings geneem is, is die spelers toegelaat om ontbyt te eet, waarna hulle weer in groepe van vier spelers elk by die laboratorium aangemeld het. Spelers is toe blootgestel aan 'n hoë-intensiteit-fiksheidssessie van 15 minute (intervensie). Bloedlaktatmetings is geneem 3 minute direk na die voltooiing van die fiksheidssessie, waarna die uitvoering van 'n 20-minuut herstelsessie gevolg het. Vir die eerste doelwit van die studie, het die eksperimentele groep 20 minute van KWO

voltooi, terwyl die kontrolegroep vir die dieselfde periode passief herstel het. Vir die tweede doelwit het die eksperimentele groep 20 minute van KWT voltooi, terwyl die kontrolegroep vir dieselfde periode passief herstel het. Die *RESTQ-Sport* is weer voltooi gedurende die oggend van die derde dag (post-herstel), 48 uur na die eerste voltooiing van die *RESTQ-Sport*.

Die ontleding van intra- en intergroepverskille vir spelers wat onderwerp is aan PH of KWO het getoon dat konflik/druk en sukses statisties ($p < 0.05$) en prakties betekenisvol ($d \sim 0.5$) afgeneem het van die prefiksheid- tot post-PHperiode. Om in vorm te wees en selfregulering is die enigste sportspesifieke stres- en herstelaktiwiteit-verwante subskale wat statisties ($p < 0.05$) en prakties betekenisvolle ($d \sim 0.5$) afnames oor dieselfde tydperk getoon het. Sosiale herstel, algemene welstand, beserings, selfdoeltreffendheid, sportspesifieke stres en herstel het ook prakties betekenisvolle afnames ($d \geq 0.3$) getoon, terwyl algemene stres en fisieke herstel prakties betekenisvolle ($d \geq 0.4$) verhogings getoon het. Die eksperimentele groep het statisties ($p < 0.05$) en prakties betekenisvolle ($d \sim 0.5$) afnames van prefiksheid tot postherstel vir sukses, algemene, sosiale en fisieke herstel getoon, terwyl beserings, om in vorm te wees, selfdoeltreffendheid, selfregulering, sportspesifieke stres en herstel almal statisties ($p < 0.05$) en groot prakties betekenisvolle ($d \sim 0.5$) afnames getoon het. Algemene stres, sosiale stres, versteurde breuke en persoonlike vervulling het prakties betekenisvolle ($d \sim 0.3$) afnames oor dieselfde tydperk getoon. Ten spyte van hierdie prefiksheid- tot postherstelveranderinge, het die normale en Quade se ontleding van kovariansie (ANKOVA) getoon dat net sportspesifieke herstel en selfdoeltreffendheid 'n meer merkbare, betekenisvolle afname ($p < 0.05$) in die eksperimentele vergeleke met die kontrolegroep getoon het.

Resultate met betrekking tot intra- en intergroepverskille tussen spelers wat onderwerp is aan PH of KWT het die volgende getoon: Vir PH was sosiale stres, fisieke klagtes, versteurde breuke en om in vorm te wees die enigste *RESTQ-Sport*-subskale wat statisties ($p < 0.05$) en medium prakties betekenisvolle ($d \geq 0.3$) afnames van prefiksheid na postherstel ervaar het. Algemene en sportspesifieke herstel sowel as selfdoeltreffendheid het almal prakties betekenisvolle ($d \sim 0.3$) afnames oor dieselfde tydperk getoon. Gebrek aan energie-subskaal het 'n statisties ($p < 0.05$) en groot prakties betekenisvolle ($d \sim 0.5$) verhoging vanaf prefiksheid tot postherstel getoon. Vir die eksperimentele groep is 'n statisties ($p < 0.05$) en medium prakties betekenisvolle ($d \sim 0.3$) toename waargeneem vir emosionele stres, terwyl selfdoeltreffendheid 'n statisties ($p < 0.05$) en medium prakties betekenisvolle ($d \sim 0.4$) toename vanaf prefiksheid na postherstel getoon het.

Fisieke klagtes en sukses het beide prakties betekenisvolle ($d \sim 0.3$) afnames oor dieselfde tydperk getoon. Ten spyte van al hierdie intragroep veranderings, het die normale ANKOVA getoon dat selfdoeltreffendheid asook sportspesifieke stres en herstel betekenisvol ($p < 0.05$) meer positief beïnvloed is deur KWT vergeleke met PH terwyl PH meer doeltreffend was in die positiewe veranderinge in emosionele stres en sukses in vergelyking met KWT oor die tydperk van 48 uur.

Dus, studieresultate dui daarop dat KWO en KWT vergeleke met PH meer voordelig was in die bevordering van 48-h *RESTQ-Sport*-subskaal-response in 'n groep rugbyspelers. Ten spyte van hierdie gevolgtrekking, het slegs 'n minderheid van *RESTQ-Sport*-subskale beter betekenisvolle herstelresponse in KWO- en KWT- vergeleke met PH-groepe, getoon. Hierdie resultate is in teenstelling met vorige bevindinge wat daarop gewys het dat KWO en KWT tot baie beter herstelresponse gelei het as PH. Nietemin, moet daar besef word dat selfs subtiele, individuele, postherstel veranderinge in *RESTQ-Sport*-subskale na afloop van 'n hoë-intensiteitsoefening, nog steeds 'n positiewe impak kan hê op spelerprestasies. 'n Meer indiepte-evaluering van spelers se psigologiese toestand word egter vereis om te bepaal watter hersteltegnieke die mees voordelige is vir die herstel van individuele spelers.

Sleutelwoorde: kouewater-onderdompeling; kontras-waterterapie; passiewe herstel; psigologiese herstel; “Recovery-Stress Questionnaire”, rugby

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List of Abbreviations

ANCOVA	Analysis of covariance
AR	Active recovery
BL	Blood lactate
CK	Creatine kinase
CPK	Serum creatine kinase
Cre	Creatinine
CWI	Cold water immersion
CWT	Contrast water therapy
°C	Degrees Celsius
DALDA	Daily Analyses of Life Demands for Athletes
DNS	Did not specify
DOMS	Delayed onset muscle soreness
EIMD	Exercise-induced muscle damage
FIR	Far-infrared therapy
HR	Heart rate
LDH	Lactate dehydrogenase
MAV	Maximal Aerobic Velocity
Min	Minutes
M_{max}	Maximal power output
MVIC	Maximal Voluntary Isometric Contraction
MVC	Maximal Voluntary Contraction
PAR	Passive recovery
POMS	Profile of Mood states
PPO	Peak power output
P-values	Probability values
RESTQ-Sport	Recovery-Stress Questionnaire for Athletes
RM	Repetition Maximum
RPE	Rate of perceived exertion
s	Seconds
STEMS	Stellenbosch Mood scale

Temp	Temperature
TQRP	Total quality of recovery perception
VA	Voluntary Activation
VAS	Visual analogue scale
W	Watts
WBC	Whole-body Cryotherapy

CHAPTER 1

1. Introduction

- 1.1 Problem statement**
 - 1.2 Objectives**
 - 1.3 Hypotheses**
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1.1 Problem Statement

Rugby Union (hereafter referred to as rugby) is an intense team sport, which involves stopping and starting at intermittent intervals (Gill *et al.*, 2006:260) over an 80-minute time period (2 halves of 40 min), with a 5-10-minute break during half-time (Junge *et al.*, 2004:169). Rugby contains aerobic as well as anaerobic exercises (Gill *et al.*, 2006:260), which include the following activities: sprinting, acceleration, rucking, mauling, tackling and breaking through tackles (Pointon & Duffield, 2012:206). These activities are interspersed with periods of lower intensity activities such as walking, jogging (Gabbett, 2002:334) and standing (Austin *et al.*, 2011:262). However, it is not just the physiological demands of rugby that players have to deal with, but also the psychological demands (Venter *et al.*, 2010:133). The physiological and psychological demands of rugby which are also exacerbated by the demanding competition regime that players face, highlight the need for recovery strategies in the training programs of team sport players (De Nardi *et al.*, 2011:609; Venter *et al.*, 2010:133; Van Wyk & Lambert, 2009:2). However, despite a growing interest in optimal recovery techniques, most studies only focus on the physiological benefits of these techniques (Lane & Wenger, 2004:859, Vaile *et al.*, 2011:829, Vaile *et al.*, 2008:431), whereas the psychological benefits and effects of such techniques are often neglected (Stacey *et al.*, 2010:663).

As it is a competitive team sport it can be assumed that rugby players experience the same psychological stress as that found in a variety of other sports (Noblet & Gifford, 2002:11). This can be ascribed to the ever-growing demands to win, fear of failure, goals which are often set too high (Wieser & Thiel, 2014:17), pressure to perform, worries about performing poorly (McKay *et al.*, 2008:144), strenuous training sessions, inadequate rest (Cresswell & Eklund, 2006:229),

performance concerns (Suzuki *et al.*, 2004:439) and constant media pressure (Noblet & Gifford, 2002:10). Research also suggests that rugby players show significantly higher levels of fatigue and a lack of energy (as measured by the Recovery-Stress Questionnaire (RESTQ-Sport)) as well as significant lower performance levels in the later weeks of competition compared to the early stages of competition (King *et al.*, 2010:228). These negative changes over a season could be attributed to a decrease in recovery levels (King *et al.*, 2010:234). Players' ability to cope with psychological stress together with their recovery state will determine how they will handle subsequent stressors and also how they will perform (Kallus & Kellmann, 2000:213). These stressors can, however, have a dramatic effect on total stress (Jeffreys, 2005:79). In view of the negative consequences of psychological stress it is important that players recover completely, not only physiologically but also psychologically.

Currently, more than sixteen established recovery techniques are used by athletes and sport practitioners in an attempt to optimise physiological recovery (Barnett, 2006:783; Coffey *et al.*, 2004:8; Junior *et al.*, 2011:500; Lane & Wenger, 2004:859; Tessitore *et al.*, 2007:745) and psychological recovery (Connolly *et al.*, 2003b:197; Delextrat *et al.*, 2013:18; Duffield *et al.*, 2014:279; Stacey *et al.*, 2010:656,663). Despite the use of a wide variety of recovery techniques, methods gaining popularity includes passive recovery (PAR), cold water immersion (CWI) and contrast water therapy (CWT) (Barnett, 2006:782; Calder, 2000:19; Lambert & Van Wyk, 2009:5; Wilcock *et al.*, 2006:195, 196).

Some coaches encourage players to rest passively (PAR) after exercise and allow the body to recover without any intervention (Lambert & Van Wyk, 2009:1). PAR generally involves that a participant sits still for the duration of the recovery period (Lattier *et al.*, 2004:510; Monedero & Donne, 2000:594). The use of PAR has been studied in numerous sports including running (Hauswirth *et al.*, 2011:e27749), soccer (Rey *et al.*, 2012:121; Tessitore *et al.*, 2007:745), cycling (Connolly *et al.*, 2003a:47) and hockey (Sayers *et al.*, 2011:293). With regard to the psychological benefit of PAR, Hauswirth and colleagues reported that PAR 48h post-exercise did not significantly reduce pain or perceived tiredness after exercise in well-trained runners (Hauswirth *et al.*, 2011:e27749).

CWI involves immersion of a body part or the whole body (excluding the head and neck) in water at a temperature of $\leq 15^{\circ}\text{C}$ for 8-20 minutes at a time (De Nardi *et al.*, 2011:613; Duffield

et al., 2014:274; Stacey *et al.*, 2010:656; Vaile *et al.*, 2011:826), and is commonly used for the treatment of inflammation, to redistribute blood flow (Vaile *et al.*, 2008:429), reduce body temperature, heart rate and thermal strain (Vaile *et al.*, 2008:436), and reduce delayed onset of muscle soreness (Glasgow *et al.*, 2014:15). This technique is used in several sports, including cycling (Vaile *et al.*, 2011:825), soccer (Rowell *et al.*, 2009:566), running (Pournot *et al.*, 2011:e22748), netball (Hamlin, 2007a:12), basketball (Delextrat *et al.*, 2013:12), and rugby (Pointon & Duffield, 2012:206), with ample scientific evidence to support its use (Barnett, 2006:782). Overall research shows that CWI is effective in reducing thermal strain and subsequently allow athletes to maintain high-intensity performance (De Pauw *et al.*, 2014:240; Peiffer *et al.*, 2010:112; Vaile *et al.*, 2008:436,437; Vaile *et al.*, 2011:825). However, only a few researchers have focused on the psychological effect of CWI. In this regard, De Nardi *et al.* (2011:613) found that CWI (15°C for 8 minutes, immersed up to the iliac spine level) resulted in significant ($p = 0.02$) lower levels of perceived fatigue compared to PAR (resting for 8 minutes) in young male soccer players during a week of training. Rowell and co-workers (2009:572) reported similar results for junior soccer players after match play with significantly lower perceptions of fatigue ($p = 0.007$) and leg soreness ($p = 0.004$) after CWI (5 x 1 min 10°C, immersed up to the mesosternal level) compared to thermoneutral treatment. Players also reported that the CWI treatment was beneficial for recovery (Rowell *et al.*, 2009:565,569). Similarly, Bahnert *et al.* (2013:155) concluded that Australian Football League (AFL) players, who chose CWI as a post-game recovery technique, had a greater perceptual recovery in the following week regarding fatigue. From the last-mentioned results it is clear that CWI is beneficial to the psychological recuperation and recovery of athletes, but more research is needed to verify the psychological benefits of CWI especially for a contact sport such as rugby.

CWT is another method that gained popularity among athletes and sports teams during recent years (Bieuzen *et al.*, 2013:e62356; Juliff, 2011:15). CWT involves immersion of different body parts or the entire body in cold water (8°-15°C, 30-60s) immediately followed by immersion in warm water (38°-42°C, 1–3.5min) for a total duration of 6 to 15 minutes (Coffey *et al.*, 2004:2,4; Gill *et al.*, 2006:261; Hamlin, 2007b:399; Sayers *et al.*, 2010:296). Researchers concluded that CWT may be a better recovery strategy for athletes due to a decrease in both blood lactate concentrations and the perception of fatigue (Coffey *et al.*, 2004:8, 9; Sayers *et al.*, 2010:301). In this regard Sayers and co-workers (2011:301) found that CWT significantly ($p < 0.00$) reduced the perception of fatigue and delayed onset of muscle soreness (DOMS) after the Wingate

Anaerobic test (maximal effort cycle ergometer test) in 14 highly trained male state representative field hockey players. Another study also showed that athletes' lower extremities felt better prepared for the next exercise session after CWT recovery from intense exercise and that the perception of better preparedness compelled players to train harder (Stacey *et al.*, 2010:663). According to Robey *et al.* (2009:256-257) CWT as a post-exercise recovery technique may have a greater psychological than a physiological effect due to athletes' perception that they have recovered. The perception of recovery may benefit physiological recovery and facilitate better performance. Despite the proven benefits and use of CWT by athletes, Barnett (2006:789) concluded that more scientific support is needed to support the use of CWT as a recovery modality.

From the above-mentioned research findings, it is clear that performing some sort of recovery technique immediately after high-intensity exercise play an important role in the enhancement of performances during subsequent exercise sessions and matches (Lane & Wenger, 2004:859). However, coaches will need to monitor athletes in order to determine the recovery status and to bring athletes back to a balanced stress-recovery state (Nel, 2012:10). Any imbalances in the stress-recovery state that are not immediately taken care of can result in overtraining and burnout (Nel, 2012:9). Certain psychometric measuring instruments such as the Stellenbosch Mood Scale (STEMS) (Terry *et al.*, 2003:232), the POMS questionnaire (McNair *et al.*, 1971), the Daily Analyses of Life Demands for Athletes questionnaire (DALDA) (Rushall, 1990), and the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) (Kellmann & Kallus, 2001; Kenttä *et al.*, 2006) are used by researchers for monitoring purposes.

Nonetheless, an advantage of the RESTQ-Sport is that it has a systematic multi-level approach that allows practitioners and sport scientists to provide recommendations that are specific to certain intervention strategies and use results to plan recovery strategies and techniques (Nel, 2012:40), which seems to be a more ideal instrument in this regard. The RESTQ-Sport does not only assess potentially stressful and restful events, but the subjective consequences of these events on both the physiological and psychological components of athletes (Kellmann & Kallus, 2001:5). Despite the value and benefits of the RESTQ-Sport no researcher have up until now investigated the psychological and physiological post-recovery responses of team sport participants by making use of this instrument. It is against this background that the following research questions were posed: Firstly, are there any differences in the 48-hour post-recovery

effects of PAR and CWI on the subscales of the RESTQ-Sport in university-level rugby players? Secondly, are there any differences in the 48-hour post-recovery effects of PAR and CWT on the subscales of the RESTQ-Sport in university-level rugby players? Answers to these questions should provide coaches and sport practitioners with more clarity concerning the most effective techniques for the psychological recovery of rugby players.

1.2 Objectives

The objectives of this study were to determine:

- The differences in the 48-hour post-recovery effects of PAR and CWI on the subscales (General Stress, General Recovery, Sport-Specific Stress and Sport-Specific Recovery) of the RESTQ-Sport in university-level rugby players; and
- The differences in the 48-hour post-recovery effects of PAR and CWT on the subscales (General Stress, General Recovery, Sport-Specific Stress and Sport-Specific Recovery) of the RESTQ-Sport in university-level rugby players.

1.3 Hypotheses

The hypotheses of the study were:

- Comparatively, CWI will have practically ($d \sim 0.3-0.5$) and statistically significant ($p \leq 0.05$) more positive 48-hour post-recovery effects on the RESTQ-Sport subscales of university-level rugby players, than PAR.
- Comparatively, CWT will have practically ($d \sim 0.3-0.5$) and statistically significant ($p \leq 0.05$) more positive 48-hour post-recovery effects on the RESTQ-Sport subscales of university-level rugby players, than PAR.

1.4 Structure of the dissertation

The dissertation is submitted in article format as approved by the Senate of the North-West University and is structured as follows:

Chapter 1: Problem statement, objectives and hypotheses. A bibliography is provided at the end of the chapter in accordance with the guidelines of the North-West University.

Chapter 2: Literature review: The effects of cold water immersion, contrast water therapy and passive recovery on the stress and recovery of rugby players. A reference list is provided at the end of the chapter in accordance with the guidelines of the North-West University.

Chapter 3: Research article 1: The 48-hour post-exercise effects of passive recovery and cold water immersion on the subscales of the Recovery-Stress Questionnaire in rugby players. This

article will be submitted for publication in the International Journal of Sport and Exercise Psychology. This chapter and the reference list at the end of the chapter were compiled in accordance with the guidelines of the last-mentioned journal (see Appendix E). Although not in accordance with the guidelines of the journal, tables were included in the text to make the article easier to read and understand. Furthermore, the line spacing of the article was set at one and a half lines and the first line of each paragraph was not indented as to conform to the layout of the rest of the dissertation.

Chapter 4: Research article 2: Differences between the 48-hour post-exercise effects of passive recovery and contrast water therapy on the subscales of the Recovery-Stress Questionnaire in rugby players. This article will be submitted for publication in the Journal of Applied Sport Psychology. This chapter and the reference list at the end of the chapter were compiled in accordance with the guidelines of the last-mentioned journal (see Appendix F). Although not in accordance with the guidelines of the journal, tables were included in the text to make the article easier to read and understand. Furthermore, the line spacing of the article was set at one and a half lines and the first line of each paragraph was not indented as to conform to the layout of the rest of the dissertation.

Chapter 5: Summary, conclusions, limitations and recommendations of the study.

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CHAPTER 2

Chapter 2

Literature review: The effects of cold water immersion, contrast water therapy and passive recovery on the stress and recovery of rugby players

2.1	Introduction
2.2	Physical and physiological demands of rugby
2.3	Psychological demand of rugby
2.4	Overtraining and burnout in sport
2.5	Recovery in sport
2.6	Recovery techniques applied in sport
2.6.1	Cold water immersion (CWI)
2.6.2	Contrast water therapy (CWT)
2.6.3	Passive recovery (PAR)
2.7	Psychometric instruments used in the assessment of stress and recovery in sport
2.7.1	Daily Analyses of Life Demands for Athletes questionnaire (DALDA)
2.7.2	The Profile of Mood States (POMS)
2.7.3	The Stellenbosch Mood Scale (STEMS)
2.7.4	The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport)
2.8	Conclusion
2.9	References

2.1 Introduction

During a rugby match, which usually lasts 80 minutes, players perform regular bouts of high-intensity (anaerobic) activities such as sprints, accelerations from a static position, rucking, mauling, tackling and breaking through tackles, which are separated by short bouts of low-intensity (aerobic) activities such as walking and jogging (Gill *et al.*, 2006:260; Pointon & Duffield, 2012:206; Suzuki *et al.*, 2004:436) and standing still (Twist & Highton, 2013:467). Consequently rugby can be regarded as an aerobic as well as an anaerobic sport (Gill *et al.*, 2006:260) which places a high physiological demand on the body (Suzuki *et al.*, 2004:436). In addition to physiological stress, players also have to deal with psychological stress (Suzuki *et al.*, 2004:436). Therefore, Van Wyk and Lambert (2009:2) stated that complete recovery from training and competition is necessary if players want to cope successfully with stress. For this reason players need to achieve an appropriate balance between training stresses and recovery if they want to maximise athletic performance (Webb, 2011:19). Also, adequate recovery after intense exercise is vital to enhance both physiological and psychological recovery (Suzuki *et al.*, 2004:436).

Various recovery modalities are gaining acceptance among elite athletes and especially professional rugby players (Lambert & Van Wyk, 2009:5). Currently more than sixteen recovery techniques which players can choose from to optimise recovery can be identified from literature and include: massage and stretching (Barnett, 2006:783; Connolly *et al.*, 2003b:203), hyperbaric oxygen therapy (HBOT) (Barnett, 2006:783), electromyostimulation (Barnett, 2006:783; Tessitore *et al.*, 2007:745), compression garments (Bahnert *et al.*, 2013:152), active (Barnett, 2006:783; Bahnert *et al.*, 2013:152) and passive recovery (Brophy-Williams *et al.*, 2011:665; Coffey *et al.*, 2004:3), cold water immersion, contrast water therapy, thermotherapy (Wilcock *et al.*, 2006a:748), carbohydrate replenishment (Halsen *et al.*, 2004b:1246), herbal remedies, nutritional supplements and pharmaceuticals (Barnett, 2006:783; Connolly *et al.*, 2003b:199, 204) as well as light-emitting diode therapy (LEDT) (Junior *et al.*, 2011:493). Cold water immersion (CWI), contrast water therapy (CWT) and passive recovery (PAR) are the recovery techniques currently used (Barnett, 2006:782; Calder, 2000:19; Lambert & Van Wyk, 2009:5; Wilcock *et al.*, 2006b:195, 196). However, despite a growing interest in these recovery techniques and the associated benefits that can be derived, most studies have neglected the psychological benefits and effects of these techniques (Stacey *et al.*, 2010:663). Currently research suggests that adequate recovery can decrease muscle soreness (Ascensão *et al.*,

2011:219; Ingram *et al.*, 2009:418), decrease the perception of fatigue (De Nardi *et al.*, 2011:610; Elias *et al.*, 2012:361), and muscle pain (Vaile *et al.*, 2008a:449) and increase the perception of recovery (Bahnert *et al.*, 2013:152; Delextrat *et al.*, 2013:14). Consequently recovery techniques may allow a coaching team to maintain a balance between physiological responses to training, training stressors and recovery. However, in order to determine balance status and to bring athletes back to a balanced stress-recovery state, coaches need to monitor athletes (Nel, 2012:10). Any imbalances in the stress-recovery state that are not immediately taken care of can result in overtraining and burnout (Nel, 2012:9).

The Profile of Mood States (POMS) questionnaire (McNair *et al.*, 1971) provides a self-assessment instrument for mood and affective states, and is frequently used to monitor athletes' psychological state during training (Kellmann, 2010:98). However, the POMS has been criticised for not being sport-specific enough (Robson-Ansley *et al.*, 2009:3). The Stellenbosch Mood Scale (STEMS), in both Afrikaans and English (Terry *et al.*, 2003b:240), is a derived and shortened version of the original POMS questionnaire. The STEMS measures the same six subscales as the original POMS questionnaire, with four items contributing to each subscale (Grobbelaar *et al.*, 2011:654). Another frequently used instrument is the Recovery-Stress Questionnaire (RESTQ-Sport) which includes measures of stress and recovery responses to sport and competition (Di Fronso *et al.*, 2013:618). This questionnaire enables coaches easily to monitor the complex psychophysiological stresses that are associated with fatigue and poor recovery (Twist & Highton, 2013:469). The Daily Analyses of Life Demands for Athletes questionnaire (DALDA) (Rushall, 1990), is also regarded to be a measuring instrument for stress related activities. The DALDA may also be a useful daily tool for developing an athlete's self-awareness of sources and symptoms of physical and psychological stressors from both the sporting and non-sporting environment (Robson-Ansley *et al.*, 2009:3). The advantage of these last-mentioned psychometric instruments is that information with regard to athletes' stressors and recovery responses is provided rapidly (Kellmann, 2010:98).

It is against this background that the subsequent literature review was compiled. The first aim of the literature review was to describe the physical, physiological and psychological demands of rugby, whereas the second aim was to discuss the characteristics and causes of overtraining and burnout. The third aim was to define the term recovery and explain the need for recovery in sport. The fourth aim was to describe CWI, CWT and PAR as well as discuss findings with

regard to the physiological and psychological effects of these recovery techniques on especially sport participants. Lastly, the fifth aim was to discuss different psychometric instruments used in the assessment of stress and recovery in sport participants.

A literature search was performed using academic databases such as EBSCO Host, MEDLINE, PsycINFO, PsycARTICLES, Sabinet, Science Direct, SPORTDiscus and Google Scholar with the following key words (although searches were not only limited to these key words): cold water immersion (CWI), contrast water therapy (CWT), passive recovery (PAR), recovery, stress-recovery, psychometric instruments, overtraining and burnout. A manual search on the computer catalogue of the library of the North-West University was also done to find relevant material on the topic. Literature for this review was narrowed down to include articles from only the last 16 years, (1999–2015) with the exception of four articles, namely Higgins and Kaminski (1998), Kuligowski *et al.* (1998), McNair *et al.* (1971, 1992) and Rushall (1990). Furthermore, searches focused on research that made use of male subjects under the age of 25 years who were active, recreational or professional athletes in especially team sports. A few studies that made use of more than one gender group were however considered in view of the important findings that were obtained (Delextrat *et al.*, 2013; Glasgow *et al.*, 2014; Hamlin, 2007b; Kuligowski *et al.*, 1998; Morton, 2007; Robey *et al.*, 2009; Vaile *et al.*, 2007; Venter *et al.*, 2010). Three studies which made use of only female subjects (Juliff, 2011; Rezaee *et al.*, 2012; Taheri *et al.*, 2012) were also included.

In the next section the physical and physiological demands of rugby will be discussed.

2.2 Physical and physiological demands of rugby

Rugby is regarded to be one of the most popular, professional team sports in the world with an estimated 6.6 million registered and unregistered players (International Rugby Board (IRB), 2015). A rugby match is highly competitive and is played by two teams of 15 players each (eight forwards and seven backs) (Junge *et al.*, 2004:169). A match is very intense and usually lasts for two 40 minute halves that are interspersed by a 10-minute break (Downey, 2010:2; Smit, 2011:21). Players need to be strong, fast, and powerful in order to gain possession of the ball during intermittent collisions with opposing players (King *et al.*, 2010b:164). Players also need to be agile, flexible and have good aerobic endurance (King *et al.*, 2010b:164). Rugby can therefore be described as an aerobic-anaerobic sport (Gill *et al.*, 2006:260).

Backs frequently need to perform tackles and focus more on running at high speeds, while forwards take part in scrums in addition to running and tackling (Mashiko *et al.*, 2004:617). In this regard professional rugby forwards perform 120–125 brief and intense actions (~ 5s in duration) per match whereas backs perform only about 50-70 actions which include high-intensity efforts such as running during a match (Jougla *et al.*, 2010:350). The high physical involvement of players during a match, leads to high workloads and rates (Smit, 2011:21). Duthie *et al.* (2006b:212) found that Super 12 rugby players performed most of their sprints over distances of between 10m and 20m whereas forwards sprinted 15m on average on 13 occasions, and backs 20m on 24 occasions. Another study found that players covered distances of between 4218m and 6389m during Super 14 matches (Austin *et al.*, 2011:262). This study also showed that back row forwards spent the greatest amount of time on high-intensity exercises (1190s), followed by the front row forwards (1015s), the inside backs (876s) and the outside backs (570s) (Austin *et al.*, 2011:262). Moreover, researchers reported that 85% of game time was spent in low and moderate intensity activities and 15% in high-intensity activities when u/19 international, elite club and Super 12 rugby games were analysed (Duthie *et al.*, 2003:984).

Furthermore, Deutsch *et al.* (2006:11) concluded that rugby players will rely on significant energy utilisation from all energy systems. During participation in rugby the anaerobic glycolysis energy system is an important source of energy for the repeated performance of high-intensity activities with a contribution of up to 50% when average work periods are approximately 5s (Deutsch *et al.*, 2006:10). In some cases forwards complete at least one work period lasting over 20s, which will lead them to rely almost solely on anaerobic glycolysis and aerobic energy sources for the latter part of play (Deutsch *et al.*, 2006:10). The same researchers also state that the work-to-rest ratio of forwards indicate that the creatine phosphate system plays a less significant role in energy provision (Deutsch *et al.*, 2006:10). However, rugby requires a high level of aerobic conditioning to facilitate recovery between high-intensity bouts during which energy is derived from anaerobic sources (Duthie *et al.*, 2005:529). The aerobic energy system will also play an important role in cases where the length of the recovery periods is shorter than 3 min (Deutsch *et al.*, 2007:471). The reason for this is that the anaerobic glycolytic and creatine phosphate energy pathways are completely inhibited, due to the brief, high-intensity periods of play that are alternated by longer periods of play which are interspersed by brief periods of recovery (Deutsch *et al.*, 2007:471). These findings were confirmed by Sparks and Coetzee, (2013:511-512), who concluded that the anaerobic glycolytic energy system was primarily used

during match play, whereas the aerobic system played a major role during recovery between match play activities.

The physical qualities of players which are developed over several years of training and competitions play an important role in the attainment of rugby success (Duthie, 2006a:2). Rugby players try to maximise their performances by spending numerous hours per day on the development of technical skills and physical training activities and by interspersing training days with rest days (Nicholls *et al.*, 2011:211). However, athletic performance will be negatively affected if coaches and athletes only focus on players' physical capabilities and neglect their psychological competence (Jeffreys, 2005:79). This point is accentuated by Jayaratnam and Dileep (2013:2) who stated that psychological stress, more than any other factor has robbed many athletes from victory and enjoyment in sport. Therefore, players need to deal with the psychological demands of rugby, apart from the above-mentioned physical and physiological demands of the sport.

2.3 Psychological demands of rugby

Rugby players are often confronted with difficult situations, setbacks and pressure on and off the field (Knobel, 2010:17). Psychological stress in rugby can be attributed to the ever-growing pressure to win, the fear of failure, goals which are often set too high (Wieser & Thiel, 2014:17), worries about performing poorly (Suzuki *et al.*, 2004:439), lack of confidence, injuries (McKay *et al.*, 2008:144), strenuous training sessions, inadequate rest (Cresswell & Eklund, 2006:229), performance concerns and constant media pressure (Noblet & Gifford, 2002:10). Extra training sessions and competitions as well as social, nutritional and educational aspects may also serve as additional sources of stress (Lehmann *et al.*, 1998:19). Players' ability to cope with psychological stress together with the recovery state determines how players will handle subsequent stressors and the influence of these stressors on performance (Kallus & Kellmann, 2000:213). Psychological stressors can have a detrimental effect on total stress and may negatively affect recovery and the level of athletic performance (Jeffreys, 2005:79; Lazarus, 2000:229). Sleep can also affect the psychological aspects of athletes' make-up by increasing or decreasing stress through relaxation and the reestablishment of well-being as well as a positive mood (Kellmann, 2002a:7).

University-level rugby players might experience increased stress levels due to among other things regimented schedules and time constraints, negative stereotyping by the media and the dual role of being both athlete and student (Surujlal *et al.*, 2012:282) which make it hard to cope. Other stressors that these players also face are: the risk of injuries (Lee *et al.*, 2001:41), personal stressors (Weinberg & Gould, 2007), playing an important game, media attention, poor refereeing, bad weather conditions, provocative opponents, mental or physical errors, enduring pain and being reprimanded by the coach (Anshel & Anderson, 2002:193; Anshel *et al.*, 2000:751). In this regard rugby players indicated that injury as well as physical and mental errors is the top three stressors they experience (Nicholls *et al.*, 2006:325). These stressors may interfere with rugby players' ability to cope, their well-being and their self-satisfaction levels (Amiot *et al.*, 2004:396, 397; Nicholls *et al.*, 2006:325). Ultimately stressors may negatively affect a player's ability to control emotions and anxiety during training and games, to cope with victories and losses, to achieve personal goals, and to focus (Amiot *et al.*, 2004:396, 397). Furthermore, anxiety may have a negative impact on player's well-being and life satisfaction (Paschali & Tsitsas, 2010:S96).

Increased stress demands and insufficient recovery lead to increased stress levels (Nel, 2012:8). Therefore, without adequate recovery it is unlikely that a player will be able to maintain a high level of performance throughout the season (Lambert & Van Wyk, 2009:2). Stress and recovery should be monitored continuously during training in order to reach optimal performance (Kellmann, 2010:100). Furthermore, the development of psychological skills (relaxing techniques, self-regulation skills, goal-setting, and motivation) can be helpful to enhance recovery and performance (Jeffreys, 2005:79, 84).

From the discussion above it is clear that rugby imposes high physiological and psychological demands on players, which are further exacerbated by the demanding competition regime that players face (De Nardi *et al.*, 2011:609; Venter *et al.*, 2010:133; Van Wyk & Lambert, 2009:2). Early detection of stressors and negative affective states will help in the prevention of overtraining and burnout, and ultimately facilitate optimal training and sport performance (Nicholls *et al.*, 2009:118).

2.4 Overtraining and burnout in sport

One way in which athletes try to improve their performances is to intensify their physical conditioning programmes (Meeusen *et al.*, 2006:1). However, intensified training is not without risk as training stress can either be positive or negative depending on the athlete's ability to adapt to the imposed training load (Polman & Houlahan, 2004:302). In cases where prolonged, excessive training stresses are applied concurrent with inadequate recovery, performance deteriorates and chronic maladaptation occurs (Armstrong & Van Heest, 2002:186). The end result of an imbalance between appropriate training stress and adequate recovery is the development of overtraining (Meeusen *et al.*, 2006:2), which is a growing concern in elite sport (Lemyre *et al.*, 2007:116). Overtraining can be defined as “an accumulation of training and non-training stress resulting in a long-term decrement in performance capacity with or without related physiological and psychological signs and symptoms of overtraining in which restoration of performance capacity may take several weeks or months” (Kreider *et al.*, 1998:viii). Overtraining is characterised by a decline in sport performance and associated physiological, biochemical, and psychological symptoms despite a lengthened recovery period (Ke-tien, 2012:1218). Some of the first signs and symptoms of prolonged training stress include a decline in performance, psychological (decreased vigour, increased fatigue) and hormonal disturbances (Halsen & Jeukendrup, 2004:968; Meeusen *et al.*, 2006:3). Other symptoms include a depressed mood, general apathy, decreased self-esteem, irritability, disturbed sleep, weight loss, loss of appetite, increased resting heart rate and an increased vulnerability to injuries (Kellmann, 2010:96).

Various factors can contribute to the symptoms of overtraining which include training, number of matches played, diet, sleep, travel and the recovery period (Nicholls *et al.*, 2011:219). Psychological factors related to overtraining may increase total mood disturbances during high intensity training (Nel, 2012:19). Overtraining can also lead to anxiety and fear (Davis *et al.*, 2006:935), emotional and physical exhaustion, sport devaluation, and a reduced sense of accomplishment (Readeke & Smith, 2001:281). In order to control factors that affect and contribute to overtraining, resting or reduced training for a period of time (weeks or months) or an improvement in the quality of recovery is necessary (Bishop *et al.*, 2008:1016; Kellmann, 2002a:14, 18).

Continued overtraining without adequate rest and recovery may lead to a phenomenon known as burnout (Weinberg & Gould, 2011:49). Overtrained athletes will usually stay motivated whereas

the burned-out athlete will typically show signs of demotivation (Lemyre *et al.*, 2007:116). Burnout is defined as “a physical, emotional and social withdrawal from a formerly enjoyable sporting activity” (Gould & Whitley, 2009:18). In addition, Raedeke (1997:398) describes burnout as a psychological syndrome of emotional and physical exhaustion due to a reduced sense of accomplishment and sport devaluation. Athletes who suffer from burnout, might experience chronic fatigue, poor sleeping patterns, episodes of depression and helplessness (Lemyre *et al.*, 2007:116).

Both overtraining and burnout can therefore be harmful and lead to serious physical and psychological problems which require special care (Gonzalez-Boto *et al.*, 2008b:636). It is therefore important that athletes prevent overtraining and burnout by implementing effective recovery strategies especially during periods when training loads are increased and athletes experience fatigue (general sensations of tiredness and decrement in physical performance) (Robson-Ansley *et al.*, 2009:1). Hence, more time for recovery is needed as stress increases. However, the balance or imbalance between stress and recovery is determined by the individual’s capacity and ability to make use of recovery resources, and by his ability to cope with stressful situations (Gonzalez-Boto *et al.*, 2008b:637). In cases where athletes’ recovery resources are sufficient, additional recovery techniques will not be needed as athletes will be able to cope well with stress (Gonzalez-Boto *et al.*, 2008b:637). In cases where recovery resources are insufficient, increases in stress will limit recovery and athletes will only be able to re-establish an optimal performance level if additional opportunities to recover are provided (Kellmann, 2002a:11). Consequently, post-exercise recovery techniques will decrease the risk and disadvantages of overtraining as it enhances the recovery process and shifts the stress-recovery balance away from training and competition-induced stressors (Barnett, 2006:782). Recovery demands are defined as the quality and/or quantity of recovery activities needed to balance the stress-state (Kellmann, 2010:96). However, in order to understand the recovery process a brief discussion thereof will be given below.

2.5 Recovery in sport

Recovery is an “inter-individual and intra-individual multilevel (e.g., psychological, physiological, social) process for the re-establishment of performance abilities” (Kellmann & Kallus, 2001:22). Recovery can be defined in different ways, but from a rugby perspective, recovery is the point at which players are able to train without constraints of sore muscles or an

increased risk of injury (Lambert & Van Wyk, 2009:5). Therefore, recovery from exercise involves that the body returns from a fatigued state towards its normal physiological and performance baseline.

Team sport athletes participate in demanding training and competition schedules, with a competitive season consisting of training and competition cycles from one week to the next (Venter, 2012:S69). These strenuous training and competition cycles place enormous demands on the psychological, physical and physiological reserves of players. The repetitive nature of the competitive season may also push athletes beyond their physiological and psychological limits (Reilly & Ekblom, 2005:626). Fast and efficient recovery is therefore important for competitive players who are involved in a training program which requires one or more high-intensity exercise sessions, games, or both in a 24-hour period (Lane & Wenger, 2004:855). However, the recovery rate is determined by the time frame between training sessions and subsequent matches (Halsen, 2011:147). In this regard, Rowsell *et al.* (2009:565) allege that competitive team-sport players do not have enough time available between training sessions and matches to recover fully on a physiological level. Limited time and the recurring imbalance between stress and recovery will compel coaches and players to place more emphasis on recovery as a greater training load and stress necessitate more recovery (Kallus & Kellmann, 2000:213). According to Kellmann (2010:97), increased levels of stress are only detrimental if players do not recovery adequately. Therefore, open days between training sessions and matches must focus on establishing the appropriate balance between recovery and training stimuli (Reilly & Ekblom, 2005:626). Adequate recovery is therefore important after intense exercise to maintain optimal performance and enhance both physiological and psychological recovery (Elena, 2014:166; Gill *et al.*, 2006:260; Mika *et al.*, 2007:475; Suzuki *et al.*, 2004:436). Without adequate recovery between periods of training and competition, it is inevitable that players will develop fatigue and increase their chances of sustaining injuries (Hing *et al.*, 2008:148).

Kraemer *et al.* (2004:126) also state that it is important for team sport athletes to enter the season in a well-recovered state. They found that athletes who had not recovered adequately tested significantly lower ($p \leq 0.05$) on muscular strength, power, and sprinting performance than those who entered the season in a well-recovered state (Kraemer *et al.*, 2004:126). Effective physiological recovery aims to replenish depleted energy stores, repair damaged tissue and remove accumulated metabolites, which results in less fatigue and allows training effects to be

maximised (Hamlin, 2007b:398). Recovery interventions which are performed with friends and teammates can also increase social recovery, which will enhance the interaction between team sport players (Kellmann, 2002a:8).

Despite above-mentioned findings researchers indicate that further research is needed to investigate the beneficial effect of recovery techniques on the psychological state of athletes (Tessitore *et al.*, 2007:749). Although Stacey *et al.* (2010:663) pointed out that most studies have not examined the psychological benefits and effects of recovery more and more studies have focused on the psychological effects of recovery in recent times (Broatch *et al.*, 2014; Delextrat *et al.*, 2013; Sayers *et al.*, 2011; Tessitore *et al.*, 2007). Furthermore, researchers recommend that coaches should make use of different recovery techniques for different players (Tessitore *et al.*, 2007:749). In addition, Jeffreys (2005:78) notes that optimum recovery strategies will vary among individuals depending upon the type of fatigue, their current levels of training and non-training stress, and their capacity to cope with stressors. Subsequently a discussion of different recovery techniques that are applied in sport as well as the physiological and psychological effects of each of these techniques will follow.

2.6 Recovery techniques applied in sport

Recovery for rugby players may reduce performance impairments on a physiological and psychological level, which contribute to a healthier, physically conditioned rugby player, and ultimately to better match performances (Smit, 2011:47). Any technique or modality that can facilitate the rate and quality of muscle repair and reduce soft tissue injuries is beneficial to an athlete who wants to return to training in an optimal state of readiness as quickly as possible (Webb, 2011:20). As has been mentioned before, the recovery techniques currently being used by athletes are CWI, CWT and PAR (Barnett, 2006:782; Calder, 2000:19; Lambert & Van Wyk, 2009:5; Wilcock *et al.*, 2006b:195, 196). Therefore the next section will focus on research that has investigated the physiological and psychological effects of each of these techniques on athletes.

2.6.1 Cold water immersion (CWI)

CWI, also commonly known as cryotherapy (meaning “cold treatment”) is a very popular post-exercise recovery technique (Vaile *et al.*, 2011:825; Webb, 2011:40). CWI refers to the immersion of a body part or the whole body (excluding the head and neck) in water with a

temperature of $\leq 15^{\circ}\text{C}$ for 8-20 minutes at a time (De Nardi *et al.*, 2011:613; Duffield *et al.*, 2014:274; Stacey *et al.*, 2010:656; Vaile *et al.*, 2011:826), and is commonly used to reduce body temperature, heart rate and thermal strain (Vaile *et al.*, 2008b:436). The use of CWI as a recovery technique has been investigated in various sports, including cycling (Vaile *et al.*, 2011:825), soccer (Rowell *et al.*, 2009:566), running (Pournot *et al.*, 2011:e22748), netball (Hamlin, 2007a:12), basketball (Delextrat *et al.*, 2013:12), and rugby (Pointon & Duffield, 2012:206).

Table 2.1 provides a summary of various CWI protocols used by researchers to examine the physiological recovery of athletes, post-exercise.

Table 2.1: Summary of studies that investigated the post-exercise effects of CWI protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Costello <i>et al.</i> (2012)	DNS	8	4 min	1	Sternum	↓ Skin temperature* ↓ Muscle and core temperature*
Delextrat <i>et al.</i> (2013)	One competitive basketball match	11	2 min	5	Iliac crest	↑ Countermovement jump performance*
Duffield <i>et al.</i> (2014)	90 min of coach-led tennis drills followed by a competitive match of 90 min	11	15 min	1	Supra-sternal notch	↓ HR* ↓ BL
Elias <i>et al.</i> (2012)	Repeated sprint ability test (6 x 20m departing every 30s)	12	14 min	1	Xiphoid process	Fully restored repeated sprint time (6 x 20m maximal sprint) performance

BL – blood lactate; **°C** – Degree Celsius; **DNS** – Did not specify; **HR** – heart rate; **Min** – minutes; **s** – seconds; **Temp.** – temperature; **W_{max}** – Maximal power output; ↓ - Decreased/lower; ↑ - Increased/better; * $p \leq 0.05$

Table 2.1 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Ingram <i>et al.</i> (2009)	80 min simulated team sport exercise and 20m shuttle run test	10	2 min x 5 min separated by 2.5 min sitting upright at room temperature 22°C	1	Umbilicus	↓ Isometric leg extension and flexion strength ↑ Return to baseline sprint performance (10 x 20m sprint)
Lane and Wenger (2004)	4 x 18 min cycling sessions on a cycle ergometer separated by 24 hours	15	15 min	1	Immersion of legs	↑ Subsequent aerobic cycling performance * No significant differences in the total work completed between the two cycling sessions

°C – Degree Celsius; **Min** – minutes; **MVIC** – Maximal Voluntary Isometric Contraction; **Temp.** – temperature; **W** – Watts; ↓ - Decreased/lower; ↑ - Increased/better; * $p \leq 0.05$

Table 2.1 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Macedo <i>et al.</i> (2014)	6 x ankle inversions (30°) on a tilt platform	4	20 min	1	Dominant leg (depth 20 cm)	↓ Skin surface temperature*
Peiffer <i>et al.</i> (2009)	Two bouts of 90 min cycling (80% of the VO ₂) followed by a 16.1 km time trial in the heat (32°C)	14	20 min	1	Mid-sternal level	↓ Rectal temperature* ↓ Skin temperature* ↓ Femoral vein diameter ↑ MVIC*
Peiffer <i>et al.</i> (2010b)	25 min cycling session (22 Watts) followed by a 4-km time trial	14	5 min	1	Mid-sternal level	↑ Average cycling power output* ↑ Repeated 4-km cycling performance* ↓ Rectal temperature*

BL – blood lactate; **°C** – Degree Celsius; **HR** – heart rate; **Min** – minutes; **MVC** – Maximal Voluntary Contraction; **Temp.** – temperature; **VA** – Voluntary Activation; ↓ - Decreased/lower; ↑ - Increased/better; * $p \leq 0.05$

Table 2.1 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Pointon <i>et al.</i> (2012)	Two times, 30 min intermittent sprint (15m sprint every minute of hard running, jogging and walking)	8.9	9 min immersion 1 min seated at room air temperature	2	Iliac crest	↓ Thermal strain* ↑ Acute recovery of MVC and VA* ↓ HR*
Rowell <i>et al.</i> (2011)	4 day soccer tournament with one full game per day	10	1 min immersion 1 min seated in ambient air (24°C) between immersions	5	Meso-sternal level	Maintained running performance over 4 matches

°C – Degree Celsius; **CK** – creatine kinase; **HR** – heart rate; **Min** – minutes; **PPO** – peak power output; Temp. – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * $p \leq 0.05$

Table 2.1 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Takeda <i>et al.</i> (2014)	80 min rugby game simulation training with tackles and body contacts	15	10 min	1	Full body (excluding head and neck)	No significant restorative effect in muscle damage after an 80 min rugby game in terms of muscle damage ↓ Body surface temperature*
Vaile <i>et al.</i> (2008a)	Seven sets of 10 eccentric repetitions on a leg press machine which were repeated 8 months later	15	14 min	1	Entire body (excluding head and neck)	↑ Squat jump performance and isometric force recovery at 48h and 72h*
Vaile <i>et al.</i> (2008b)	30 min cycling task that consisted of 15 min at 75% peak power output followed by a 15 min time trial	15	10 min	1	Full body (excluding head and neck)	↓ Thermal strain ↓ HR* ↓ Mean body temperature* Maintained high-intensity cycling performance

°C – Degree Celsius; **CK** – creatine kinase; **HR** – heart rate; **Min** – minutes; **PPO** – peak power output; Temp. – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * $p \leq 0.05$

Table 2.1 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Vaile <i>et al.</i> (2011)	All-out 35 min cycling bout that consisted of 15 min at a fixed workload (75% individual's PPO) followed by a 15 min performance time trial	15	15 min	1	Full body (excluding head and neck)	Maintained repeated cycling performance in the heat ↓ Rectal temp, limb blood flow and HR*
Webb <i>et al.</i> (2013)	Three competitive rugby matches followed by a recovery session 1h after the match	10-12	5 min	1	Anterior superior iliac spine	↑ Jump height performance ↓ CK at 42h post-game

°C – Degree Celsius; **CK** – creatine kinase; **HR** – heart rate; **Min** – minutes; **PPO** – peak power output; Temp. – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * $p \leq 0.05$

From the tabulated results, a few conclusions can be made regarding the physiological effect of CWI on athletes, post-exercise. Although inconsistent, several investigators demonstrated the following benefits of short duration (i.e. less than 10 min of) CWI: a significant decreased skin, muscle and core temperature ($p < 0.05$) in active males after 4 min of CWI (Costello *et al.*, 2012:e48190); a significant increase in countermovement jump performance ($p = 0.03$) after a competitive basketball match (Delextrat *et al.*, 2013:16); significant increases in average cycling power output and 4-km time trial cycling performance ($p < 0.05$) as well as a significant decrease in rectal temperature ($p < 0.01$) after 5 min of CWI (Peiffer *et al.*, 2010b:463); maintenance of running performance over four soccer matches (Rowell *et al.*, 2011:2); a significant decrease ($p < 0.05$) in surface body temperature (Takeda *et al.*, 2014:619); a significant decrease in thermal strain, heart rate and mean body temperature ($p < 0.05$), as well as maintained high-intensity cycling performance (Vaile *et al.*, 2008b:433). However, evidence to the contrary with regard to the efficacy of short term CWI strategies for team sport participants has also emerged. For example, CWI (10 min x 1 at 15°C) after 80 min of a simulated rugby game consisting of tackles and body contacts provided no restorative effect in muscle damage (Takeda *et al.*, 2014:619), whereas CWI (5 min x 1 at 10-12°C) after three competitive rugby games led to a non-significant increase in jump height performance as well as a non-significant decrease in creatine kinase at 42h post-game (Webb *et al.*, 2013:2450).

On the other hand, CWI between 14 and 15 min appears to be more effective as a recovery technique. In this regard 15 min of CWI caused significant decreases ($p < 0.05$) in heart rate after 90 min of coach-led tennis drills followed by 90 min of a competitive tennis match (Duffield *et al.*, 2014:274, 276). CWI of 14 min at 15°C also led to significant increases ($p < 0.05$) in squat jump performance and isometric force recovery at 48h and 72h after seven sets of 10 eccentric leg press repetitions as well as the maintenance of repeated cycling performance in the heat (Vaile *et al.*, 2008a:449). Fourteen min of CWI at 12°C after a repeated sprint ability test also restored repeated sprint performance (Elias *et al.*, 2012:361).

However, in some cases CWI of between 14 and 15 min did not succeed in bringing about significant post-exercise changes. For example, 15 min of CWI at 11°C after 90 min of coach-led tennis drills and a competitive match of 90 min led to a non-significant decrease ($p > 0.05$) in tennis players' blood lactate levels (Duffield *et al.*, 2014:276). In addition, 15 min of CWI at 15°C led to no significant differences ($p > 0.05$) in total work completed between two cycling

sessions (Lane & Wenger, 2004:856). A longer duration of CWI (20 min) caused a significant decrease ($p < 0.05$) in skin surface (Macedo *et al.*, 2014:94), rectal and skin temperature as well as a significant decrease ($p < 0.05$) in femoral vein diameter and increase ($p < 0.05$) in maximal isometric contraction (Peiffer *et al.*, 2009:93).

Multiple CWI exposures can also assist recovery. In this regard, CWI (2 minutes x 5 minutes separated by 2.5 min of passive seated rest at 10°C) applied immediately and 24h after 80 min of simulated team-sports running (4 x 20 min quarters) resulted in a non-significant decrease ($p > 0.05$) in isometric leg extension and flexion strength and a non-significant increase ($p > 0.05$) in the return to baseline sprint performance after 80 min of a simulated team sport exercise (Ingram *et al.*, 2009:418, 419). CWI at 8.9°C (2 x 9 min immersions separated by 1 min sitting at room temperature) after a 30 min intermittent sprint also resulted in a significant decrease ($p = 0.00$) in thermal strain and heart rate as well as a significant increase ($p = 0.00$) in maximal voluntary muscle contraction and activation (Pointon *et al.*, 2012:2485, 2489).

From the above-mentioned discussion it is clear that protocols for CWI vary considerably between studies. In summary, evidence suggests that CWI has the potential to be used as an effective post-exercise recovery technique, although benefits of this technique for use in team sport participants are not well-researched and are inconsistent. Furthermore, although various researchers have highlighted the physiological benefits of CWI as a post-exercise recovery technique, others have also pointed to the psychological benefits that can be derived from CWI.

Table 2.2 provides a summary of various CWI protocols used by researchers to examine the psychological recovery of athletes, post-exercise.

Table 2.2: Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Ascensão <i>et al.</i> (2011)	One soccer match	10	10 min	1	Iliac crest	↓ Muscle soreness (Muscle soreness Questionnaire) ↓ Perception of muscle soreness*
Bahnert <i>et al.</i> (2013)	One AFL competitive game	6-11	8 min	1	Up to the hip	↑ Perception of recovery* (Fit Sense computer-based questionnaire)
Broatch <i>et al.</i> (2014)	Four 30s all-out efforts (resistance: 7.5% of body mass) on a cycle ergometer interspersed by 4 min rest	14	15 min	1	Up to umbilicus	↑ Ratings of physical and mental readiness for exercise*
Brophy-Williams <i>et al.</i> (2011)	Eight high intensity running, treadmill intervals (3 min long at 90% of VO _{2max} velocity)	15	15 min	1	Mid-sternum	↑ Perception of recovery*

°C – Degree Celsius; **AFL** – American Football League; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.2 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
De Nardi <i>et al.</i> (2011)	Training session that consisted of soccer-specific running drills, dynamic stretches, performance tests [countermovement jump, repeated sprints (12 x 20m, 20s rest), 5 min shuttle runs (12 km/h), 30 min of training (low intensity) and small-sided games (4 x 4 min)]	15	8 min	1	Iliac spine	↓ Perception of fatigue*
Delextrat <i>et al.</i> (2013)	One competitive basketball match	11	2 min	5	Iliac crest	↓ Perception of fatigue* ↓ Perception of leg soreness* ↓ Perception of leg pain*

°C – Degree Celsius; **M** – meter; **Min** – minutes; **S** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.2 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Duffield <i>et al.</i> (2014)	90 min of coach-led tennis drills followed by a competitive match of 90 min	11	15 min	1	Supra-sternal notch	↓ Perception of muscle soreness*
Elias <i>et al.</i> (2012)	Repeated sprint ability test (6 x 20m departing every 30s)	12	14 min	1	Xiphoid process	↓ Perception of fatigue and muscle soreness
Goodall and Howatson (2008)	Five sets of 20 drop jumps from a height of 0.6m with 10s rest between each jump and 2 min rest between sets	15	12 min	1	Iliac crest	No significant effect on recovery following muscle damage

°C – Degree Celsius; **M** – meter; **Min** – minutes; **S** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.2 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Ingram <i>et al.</i> (2009)	80 min of a simulated team sport exercise and 20m shuttle run test	10	2 min x 5 min separated by 2.5 min sitting upright at room temperature (22°C)	1	Up to umbilicus	↓ Muscle soreness*
Junior <i>et al.</i> (2011)	Wingate test at maximal speed for 30s (7.5% of body mass resistance)	5	5 min	1	Lower limbs below the gonadal region	No significant differences in work performed

°C – Degree Celsius; **M** – meter; **Min** – minutes; **S** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.2 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Kinugasa and Kilding (2009)	A 90 min soccer match	12	10 min	1	Up to neck	Perceived less stiff and heavy legs ↑ Quality of recovery
Montgomery <i>et al.</i> (2008)	A 3-day basketball tournament involving a full 48 min game per day	11	1 min	5	Meso-sternal level	↓ Fatigue and muscle soreness
Pointon <i>et al.</i> (2012)	Two sets 30 min intermittent sprints (a 15m sprint every minute of hard running, jogging and walking)	8.9	9 min immersion 1 min seated (at room temp.)	2	Iliac crest	↓ Perception of muscle soreness* ↓ Ratings of thermal strain* (10-point Likert Scale)

°C – Degree Celsius; **Min** – minutes; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.2 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Pointon and Duffield (2012)	Three sets of two 30 min sprint protocols with tackling on a 20 m running track with 5 intense lower-body tackles (40 tackles in total) separated by 10s every 6 th min	9.2	9 min immersion 1 min seated (at room temp.)	2	Iliac crest	↓ Perception of muscle soreness* (Muscle soreness Scale)
Rowell <i>et al.</i> (2009)	Four soccer matches in 4 days with 24h rest between matches and a recovery session after each match	10	1 min	5	Meso-sternal level	↓ General fatigue* ↓ Perception of leg soreness*

°C – Degree Celsius; **Min** – minutes; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.2 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Rowse et al. (2011)	4 Day soccer tournament with one full game per day	10	1 min immersion 1 min seated in ambient air (24°C) between immersions	5	Meso-sternal level	↓ Muscle soreness ↓ Ratings of leg soreness* ↓ Ratings of general fatigue*
Stacey et al. (2010)	Three bouts of 50-Kj (equated to 2 km) cycling with a recovery session after each bout	10	10 min	1	Up to neck	↓ Sensation of fatigue* Perception that lower extremities felt better prepared*

°C – Degree Celsius; **Min** – minutes; **RPE** – Rate of perceived exertion; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.2 (cont.): Summary of studies that investigated the post-exercise effects of CWI protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWI Temp. (°C)	Application time	Repeats	Level of immersion	Main findings
Takeda <i>et al.</i> (2014)	80 min rugby game simulation training which contained tackles and body contacts	15	10 min	1	Full body (excluding head and neck)	No restorative effect after muscle damage ↓ Feelings of fatigue*
Vaile <i>et al.</i> (2008b)	A 30 min cycling task that consisted of 15 min at 75% of peak power output followed by a 15 min time trial	15	10 min	1	Full body (excluding head and neck)	Ineffective in reducing perception of effort/pain
Webb <i>et al.</i> (2013)	Three competitive rugby games followed by a recovery session 1h after game	10-12	5 min	1	Anterior superior iliac spine	↓ Muscle soreness

°C – Degree Celsius; **Min** – minutes; **RM** – repetition maximum; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

From Table 2.2 it is clear that the majority of researchers used CWI temperatures of between 10 and 15°C (Ascensão *et al.*, 2011; Bahnert *et al.*, 2013; Broatch *et al.*, 2014; Brophy-Williams *et al.*, 2011; De Nardi *et al.*, 2011; Delextrat *et al.*, 2013; Duffield *et al.*, 2014; Elias *et al.*, 2012; Goodall & Howatson, 2008; Ingram *et al.*, 2009; Kinugasa & Kilding, 2009; Montgomery *et al.*, 2008; Rowsell *et al.*, 2009; Rowsell *et al.*, 2011; Stacey *et al.*, 2010; Takeda *et al.*, 2014; Vaile *et al.*, 2008b; Webb *et al.*, 2013) in the examination of the psychological recovery benefits of CWI. Some researchers applied different water temperatures which include 5°C (Junior *et al.*, 2011), 8.9°C (Pointon *et al.*, 2012), and 9.2°C (Pointon & Duffield, 2012) amongst others. Application times varied between 5 and 15 min (Ascensão *et al.*, 2011; Bahnert *et al.*, 2013; Broatch *et al.*, 2014; Brophy-Williams *et al.*, De Nardi *et al.*, 2011; Delextrat *et al.*, 2013; Duffield *et al.*, 2014; Elias *et al.*, 2012; Goodall & Howatson, 2008; Ingram *et al.*, 2009; Junior *et al.*, 2011; Kinugasa & Kilding, 2009; Montgomery *et al.*, 2008; Pointon *et al.*, 2012; Pointon & Duffield, 2012; Rowsell *et al.*, 2009; Rowsell *et al.*, 2011; Stacey *et al.*, 2010; Takeda *et al.*, 2014; Vaile *et al.*, 2008b; Webb *et al.*, 2013), with the majority of researchers applying 10 to 15 min of CWI (Ascensão *et al.*, 2011; Broatch *et al.*, 2014; Brophy-Williams *et al.*, Delextrat *et al.*, 2013; Duffield *et al.*, 2014; Elias *et al.*, 2012; Goodall & Howatson, 2008; Ingram *et al.*, 2009; Kinugasa & Kilding; Rowsell *et al.*, 2011; Stacey *et al.*, 2010; Takeda *et al.*, 2014; Vaile *et al.*, 2008a).

Although inconsistent, several researchers found that CWI of less than 10 min led to a significant decrease ($p < 0.05$) in the perception of muscle soreness after one soccer match (Ascensão *et al.*, 2011:221); a significant increase ($p < 0.05$) in the perception of recovery after one American Football League (AFL) match (Bahnert *et al.*, 2013:152); a significant decrease ($p = 0.02$) in the perception of fatigue after specific soccer drills (De Nardi *et al.*, 2011:613); significant decreases ($p < 0.00$) in the perception of leg soreness, leg pain and muscle soreness after one competitive basketball match (Delextrat *et al.*, 2013:14, 15); significant decreases ($p = 0.00$) in general fatigue and the perception of leg soreness after four soccer matches (Rowsell *et al.*, 2009:569); significant decreases ($p = 0.00$) in the ratings of leg soreness and general fatigue ($p = 0.01$) after a four day soccer tournament (Rowsell *et al.*, 2011:2); a significant decrease ($p < 0.05$) in the sensation of fatigue and the perception that lower extremities felt better prepared after three bouts of 2km cycling sessions (Stacey *et al.*, 2010:658, 660); a significant increase ($p < 0.05$) in the quality of recovery as well as a significant decrease ($p < 0.05$) in feelings of fatigue after an 80 min simulation rugby game (Takeda *et al.*, 2014:619).

However, some non-significant differences ($p > 0.05$) were also found which included a decrease in muscle soreness after exercise sessions (Ascensão *et al.*, 2011:219; Montgomery *et al.*, 2008:3; Rowsell *et al.*, 2011:2); non-significant differences in work performed after a maximal sprint Wingate test (Junior *et al.*, 2011:497); a non-significant increase in the quality of recovery and the perception of less stiff and heavy legs after a 90 min soccer match (Kinugasa & Kilding, 2009:1402).

On the other hand, CWI applied for more than 10 min (between 11 and 15 min) caused a significant increase ($p < 0.05$) in the ratings of physical and mental readiness for exercise after a 30s all-out cycling session (Broatch *et al.*, 2014:2143); a significant increase ($p = 0.00$) in the perception of recovery after eight high-intensity treadmill running bouts (Brophy-Williams *et al.*, 2011:668); a significant decrease ($p < 0.05$) in the perception of muscle soreness after 90 min of coach-led tennis drills followed by a competitive 90 min match (Duffield *et al.*, 2014:276) as well as after 80 min of a simulated team sport exercise (Ingram *et al.*, 2009:419) and 2h after a 30 min sprint protocol (Pointon & Duffield, 2012:7, 15); as well as a significant decrease ($p = 0.01$) in the ratings of thermal strain after two sets of 30 min intermittent sprints (Pointon *et al.*, 2012:2490). However, recovery was not significantly influenced ($p > 0.05$) by CWI after 5 sets of 20 drop jumps (Goodall & Howatson, 2008:236). Various studies also showed that CWI of between 10 and 15 min in duration at water temperatures of between 10 and 12°C effectively reduced ($p < 0.05$) the perception of muscle soreness, directly after soccer matches (Ascensão *et al.*, 2011:221; Rowsell *et al.*, 2009:566), a tennis match (Duffield *et al.*, 2014:276) and a repeated-sprint ability session (Elias *et al.*, 2012:361).

In some cases results suggest that CWI that was executed over a longer duration of time (at least 10 min), was more effective at inducing positive changes compared to CWI of a shorter duration (i.e. 4-6 min). For example, CWI for 10 min led to a significant decrease ($p < 0.05$) in muscle soreness (Ascensão *et al.*, 2011:221; Ingram *et al.*, 2009:419); decreased thermal strain, heart rate and maintained subsequent high-intensity cycling performance which resulted in a decrease in total work after a 30 min exercise cycling task (Vaile *et al.*, 2008b:436).

Then again, in certain cases CWI was not effective either in bringing about positive changes in psychological recovery-related parameters. For example, CWI (14 min at 15°C) was ineffective in decreasing pain perception after eccentric exercises (7 x 10 eccentric exercises on a leg press

machine) (Vaile *et al.*, 2008b:435). Similarly, CWI (10 min at 15°C) did not reduce the perception of effort compared to active recovery (Vaile *et al.*, 2008b:435) or restored muscle damage after an 80 min simulated rugby game (Takeda *et al.*, 2014:620).

Overall results suggest that CWI can be effective in reducing perceptions of fatigue and muscle soreness as well as increase perceptions of recovery, which may enable athletes to maintain high-intensity performance (Peiffer *et al.*, 2010a:112; Vaile *et al.*, 2008b:436, 437; Vaile *et al.*, 2011:825). Nonetheless, only a limited number of researchers examined the possible benefits of CWI on the psychological recovery of athletes, which accentuates the need for more research in this area. Additionally, protocols for CWI vary considerably between studies which made it difficult to compare CWI-related studies and to determine which protocols are the most effective for the psychological recovery of athletes, especially rugby players. Consequently, more research is required to establish the efficacy of different CWI protocols for the psychological recovery of athletes, especially rugby players.

Another problem that researchers are confronted with is that studies show certain limitations that must be considered when interpreting results. In this regard one study only made use of active and healthy individuals and not of athletes (Macedo *et al.*, 2014:96). Other limitations include small sample sizes of between 9 and 20 participants (Rowse *et al.*, 2011:6; Stacey *et al.*, 2010:663), the absence of a control group (Ascensão *et al.*, 2011:224) and small effect sizes which limit the practical application of studies (Delextrat *et al.*, 2013:18). Furthermore, an inability to blind subjects to the recovery treatment highlights an intrinsic limitation of CWI research (Peiffer *et al.*, 2010b:464).

CWT is another method that gained popularity among athletes and sport teams during recent years (Bieuzen *et al.*, 2013:e62356; Juliff, 2011:15).

2.6.2 Contrast water therapy

CWT involves immersion of different body parts or the entire body in cold water (8°-15°C) for a duration of between 30 and 60s, immediately followed by warm water immersion (38°-42°C) for 1 to 3.5 min to bring the total duration of CWT to between 6 and 15 min (Coffey *et al.*, 2004:2, 4; Gill *et al.*, 2006:261; Hamlin, 2007b:399; Sayers *et al.*, 2011:296). The next section will

present a brief summary of CWT protocols used by researchers to examine the physiological recovery of athletes, post-exercise (Table 2.3).

Table 2.3: Summary of studies that investigated the post-exercise effects of CWT protocols on the physiological recovery of athletes

Authors	Exercise protocol	CWT Temperature (°C)		Application time		Repeats	Level of immersion	Main findings
		Hot	Cold	Hot	Cold			
French <i>et al.</i> (2008)	Six sets of 10 squats at 100% of body mass and one eccentric squat at 1RM	37-40	8-10	3 min	1 min	4 (cold) 3 (hot)	Seated upright in bath depth of 50cm	No significant difference in performance
Gill <i>et al.</i> (2006)	Elite rugby players were monitored over four matches followed by a recovery session after each match	40-42	8-10	2 min	1 min	3	Anterior superior iliac spine	↑ in CK concentration*

BL – blood lactate; **°C** – Degree Celsius; **CK** – creatine kinase; **HR** – heart rate; **Min** – minutes; **RM** – repetition maximum; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * $p \leq 0.05$

Table 2.3 (cont.): Summary of studies that investigated the post-exercise effects of CWT protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWT Temp. (°C)		Application time		Repeats	Level of immersion	Main findings
		Hot	Cold	Hot	Cold			
Hamlin <i>et al.</i> (2007b)	20m Multistage fitness test followed by a repeated sprint test (6 x 5,10 and 15m shuttles on 30s)	38	8-10	1 min	1 min	3	Leg immersion (cold) Shower directed on legs (hot)	↓ BL concentration ↓ HR No significant difference in repeated sprint performance
Morton (2007)	Four 30s Wingate cycle tests	36	12	4 min	1 min	5	Gluteal fold	↓ Plasma lactate concentration* ↓ BL 30min post-exercise
Robey <i>et al.</i> (2009)	Stair climb running (3.6 km, 242 stairs)	40	12	2 min	1 min	5	Waist deep	No significant differences in concentric leg extension strength

BL – blood lactate; **°C** – Degree Celsius; **HR** – heart rate; **Min** – minutes; **RM** – repetition maximum; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.3 (cont.): Summary of studies that investigated the post-exercise effects of CWT protocols on the physiological recovery of athletes

Authors	Exercise Protocol	CWT Temp. (°C)		Application time		Repeats	Level of immersion	Main findings
		Hot	Cold	Hot	Cold			
Sayers <i>et al.</i> (2011)	Two 30s maximal intensity Wingate tests	38	15	3.5 min	30 sec	3	Jugular notch	↓ BL concentration* ↑ Return to baseline values (HR and Blood pressure)* ↓ Venous pooling* ↓ in power decline*
Vaile <i>et al.</i> (2007)	Eccentric leg press protocol (5 x 10 repetitions)	40-42	8-10	2 min	1 min	5	Waist deep	↑ Squat force and jump squat performance* ↓ Symptoms of DOMS*

BL – blood lactate; **°C** – Degree Celsius; **DOMS** – Delayed Onset of Muscle Soreness; **HR** – heart rate; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

From Table 2.3 it is clear that the majority of researchers used temperatures of between 8 and 15°C for the CWI part of CWT (French *et al.*, 2008; Gill *et al.*, 2006; Hamlin *et al.*, 2007b; Morton, 2007; Robey *et al.*, 2009; Sayers *et al.*, 2011; Vaile *et al.*, 2007), and 40°C as the water temperature for hot water immersion (French *et al.*, 2008; Gill *et al.*, 2006; Robey *et al.*, 2009; Vaile *et al.*, 2007). Only three groups of researchers used colder water temperatures (36-38°C) for hot water immersion when CWT was applied (Hamlin *et al.*, 2007b; Morton, 2007; Sayers *et al.*, 2011).

Application times varied from a total recovery time of 6 up to 15 min, consisting of 3 min (hot) repeated 4 times and 1 min (cold) repeated 3 times (French *et al.*, 2008); 2 min (hot) and 1 min (cold) repeated 3 times (Gill *et al.*, 2006); 1 min (hot) and 1 min (cold) repeated 3 times (Hamlin *et al.*, 2007b); 4 min (hot) and 1 min (cold) repeated 5 times (Morton, 2007); 2 min (hot) and 1 min (cold) repeated 5 times (Robey *et al.*, 2009); 3.5 min (hot) and 30s (cold) repeated 3 times (Sayers *et al.*, 2011) and 2 min (hot) with 1 min (cold) repeated 5 times (Vaile *et al.*, 2007).

Exposures of less than 10 min caused a significant increase ($p < 0.01$) in creatine kinase concentration after four rugby matches (Gill *et al.*, 2006:261), as well as a non-significant decrease ($p > 0.05$) in blood lactate concentration, heart rate and no significant difference ($p > 0.05$) in repeated sprint performance after fitness tests and a repeated sprint test (Hamlin *et al.*, 2007b:401). Exposures of more than 10 min caused a significant decrease ($p < 0.00$) in blood lactate concentrations and a significant decrease ($p = 0.00$) in power decline, a significant increase ($p < 0.00$) in return to baseline values (heart rate and blood pressure), and a significant decrease ($p < 0.00$) in venous pooling after two 30s maximal intensity Wingate tests (Sayers *et al.*, 2011:297, 298). CWT also led to a significant increase ($p < 0.05$) in squat force and jump squat performance after an eccentric leg press protocol, as well as a significant decrease ($p < 0.05$) in symptoms of DOMS after an eccentric leg press protocol (Vaile *et al.*, 2007:698, 699). However, non-significant results were also found, which included no significant differences ($p > 0.05$) in strength performance after exercise-induced muscle damage (French *et al.*, 2008:1297) and no significant differences ($p > 0.05$) in strength performance (leg extension peak torque) after stair climb running (Robey *et al.*, 2009:252).

Similar to CWI, the above-mentioned literature shows that protocols for CWT vary considerably between studies and more clarity is needed concerning the most effective protocol design for

bringing about physiological recovery in athletes, especially rugby players. In addition, it is evident from the above-mentioned discussion that contrasting results exist with regard to the effectiveness of CWT for the physiological recovery of athletes, post-exercise.

In the next section a brief summary of the effects of CWT on the psychological recovery of athletes, post-exercise follow (Table 2.4).

Table 2.4: Summary of studies that investigated the post-exercise effects of CWT protocols on the psychological recovery of athletes

Authors	Exercise protocol	CWT Temp (°C)		Application time		Repeats	Level of immersion	Main findings
		Hot	Cold	Hot	Cold			
Coffey <i>et al.</i> (2004)	Treadmill runs to exhaustion at 120% and 90% of peak running speed	42	10	2 min	1 min	5	Anterior superior iliac spine	↓ Perception of fatigue, discomfort and stress
De Nardi <i>et al.</i> (2011)	A training session that consisted of soccer specific running drills, dynamic stretches, performance tests (countermovement jump, repeated sprint (12 x 20m, 20s rest), 5 min of shuttle runs (12 km/h), 30 min of training (low intensity) and small-sided games (4 x 4 min)	28	15	2 min	2 min	2	Iliac spine	↓ Perception of fatigue

°C – Degree Celsius; **EIMD** – Exercise Induced Muscle Damage; **Min** – minutes; **RM** – repetition maximum; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.4 (cont.): Summary of studies that investigated the post-exercise effects of CWT protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWT Temp (°C)		Application time		Repeats	Level of immersion	Main findings
		Hot	Cold	Hot	Cold			
French <i>et al.</i> (2008)	Six sets of 10 squats at 100% of body mass and one eccentric squat at 1 RM	37-40	8-10	3 min	1 min	4 (cold) 3 (hot)	Seated upright in bath depth of 50cm	↓ Muscle soreness
Gill <i>et al.</i> (2006)	Elite rugby players were monitored over four matches which were followed by a recovery session after each match	40-42	8-10	2 min	1 min	3	Anterior superior iliac spine	↓ Perceptions of fatigue*
Glasgow <i>et al.</i> (2014)	Three DOMS induction eccentric hamstring curls (standing hamstring curl machine at 6°)	38	10	1 min	1 min	3	Up to waist level in a standing position	No significant differences between groups at baseline

°C – Degrees Celsius; **DOMS** – Delayed Onset of Muscle Soreness; **Min** – minutes; **RM** – repetition maximum; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.4 (cont.): Summary of studies that investigated the post-exercise effects of CWT protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWT Temp (°C)		Application time		Repeats	Level of immersion	Main findings
		Hot	Cold	Hot	Cold			
Ingram <i>et al.</i> (2009)	An eight minute simulated team sport exercise and a 20m shuttle run test	40	10	2 min	2 min	3	Level of umbilicus	↓ Muscle soreness 24h post-exercise*
King and Duffield (2009)	Four 15 min long intermittent sprint simulated netball circuit	39	10	2 min	1 min	5	Iliac crest	↓ Muscle soreness
Kuligowski <i>et al.</i> (1998)	Five sets of 10 repetitions of eccentric elbow extensions with a weight that was 2.27kg heavier than the 1RM	38.9	12.8	3 min	1 min	6	Submerged arm up to mid-deltoid level	↑ Return of perceived arm muscle soreness*
Morton (2007)	Four sets of 30s Wingate cycle tests	36	12	4 min	1 min	5	Up to gluteal fold	Accelerated recovery ↑ Blood lactate clearance*

°C – Degrees Celsius; **Min** – minutes; **RM** – repetition maximum; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better;

* - $p \leq 0.05$

Table 2.4 (cont.): Summary of studies that investigated the post-exercise effects of CWT protocols on the psychological recovery of athletes

Authors	Exercise Protocol	CWT Temp (°C)		Application time		Repeats	Level of immersion	Main findings
		Hot	Cold	Hot	Cold			
Robey <i>et al.</i> (2009)	Stair climb running (3.6 km, 242 stairs)	40	12	2 min	1 min	5	Waist deep	No significant differences in muscle soreness
Sayers <i>et al.</i> (2011)	Two sets of 30s maximal intensity Wingate tests	38	15	3.5 min	30 sec	3	Up to jugular notch	↓ Ratings of fatigue*
Vaile <i>et al.</i> (2007)	DOMS inducing leg press protocol (5 x 10 repetitions of eccentric bilateral leg press)	40-42	8-10	2 min	1 min	5	Waist deep	Significant increases in perceived leg muscle pain (VAS)*
Vaile <i>et al.</i> (2008a)	Seven 10 eccentric repetitions on a leg press machine which were repeated 8 months later	38	15	1 min	1 min	7	Entire body (excluding head and neck)	↓ Perception of muscle pain*

°C – Degrees Celsius; **DOMS** – Delayed Onset of Muscle Soreness; **Min** – minutes; **s** – seconds; **Temp.** – temperature; **VAS** – Visual Analogue Scale; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Results (Table 2.4) show that the majority of researchers used temperatures of between 8 and 15°C (Coffey *et al.*, 2004; De Nardi *et al.*, 2011; French *et al.*, 2008; Gill *et al.*, 2006; Glasgow *et al.*, 2014; Ingram *et al.*, 2009; King & Duffield, 2009; Kuligowski *et al.*, 1998; Morton, 2007; Robey *et al.*, 2009; Sayers *et al.*, 2011; Vaile *et al.*, 2007; Vaile *et al.*, 2008a) for the CWI part of CWT and between 36°C and 40°C for hot water immersion (French *et al.*, 2008; Gill *et al.*, 2006; Glasgow *et al.*, 2013; Ingram *et al.*, 2009; King & Duffield, 2009; Kuligowski *et al.*, 1998; Morton, 2007; Robey *et al.*, 2009; Sayers *et al.*, 2011; Vaile *et al.*, 2007; Vaile *et al.*, 2008a). Only two groups of researchers used different water temperatures - a warmer water temperature of 42°C (Coffey *et al.*, 2004) and a colder water temperature of 28°C, respectively when CWT was applied (De Nardi *et al.*, 2011).

Exposures of less than 10 min in total resulted in a non-significant decrease ($p > 0.05$) in the perception of fatigue after specific soccer training drills (De Nardi *et al.*, 2011:613); a non-significant decrease ($p > 0.05$) in muscle soreness after exercise-induced muscle damage (French *et al.*, 2008:1297); no significant differences ($p > 0.05$) between groups at baseline after three DOMS inducing exercises (Glasgow *et al.*, 2014:10) and a significant decrease ($p < 0.05$) in the perception of fatigue after four rugby matches (Gill *et al.*, 2006:261). However, exposures of more than 10 min in total resulted in a non-significant decrease ($p > 0.05$) in the perception of fatigue, discomfort and stress after exhaustive treadmill runs (Coffey *et al.*, 2004:8) and a non-significant decrease ($p > 0.05$) in muscle soreness after 4 x 15 min long intermittent sprint simulated netball circuits (King & Duffield, 2009:1795). CWT of 15 min in duration also led to no significant differences ($p > 0.05$) in muscle soreness after stair climb running compared to stretching and PAR (Robey *et al.*, 2009:251). CWT also led to significant ($p < 0.01$) increases in perceived leg muscle pain (VAS) after a DOMS inducing leg press protocol (Vaile *et al.*, 2007:700); a significant decrease ($p < 0.05$) in muscle soreness 24h after a simulated team sport exercise of 80 min (Ingram *et al.*, 2009:419) and a significant increase ($p < 0.01$) in the return of perceived arm muscle soreness after eccentric elbow extensions (Kuligowski *et al.*, 1998:224). CWT of more than 10 min also led to an accelerated recovery (due to a significant increase ($p < 0.00$) in blood lactate clearance) after 4 x 30s Wingate tests (Morton, 2007:468); a significant decrease ($p < 0.00$) in the ratings of perceived fatigue after 2 x 30s Wingate tests (Sayers *et al.*, 2011:300) as well as a significant decrease ($p < 0.01$) in the perception of muscle pain after 7 sets of 10 eccentric leg press repetitions (Vaile *et al.*, 2008a:450). Furthermore, CWT hastened blood lactate clearance, resulted in lighter and less tight muscles as well as a

feeling of mental freshness, and improved the subjective perception of recovery (Morton, 2007:469).

However, certain limitations need to be considered when interpreting results of CWT-related studies. For example, researchers have not focused on the possible effects of CWT on the psychological state of athletes. Furthermore, most researchers made use of simulated competition-related or laboratory based interventions to investigate the effectiveness of CWT as a recovery technique instead of real life competitions or training sessions (Sayers *et al.*, 2011:301). Moreover, to date very few researchers have compared the effectiveness of CWT to CWI and PAR for the recovery of athletes. Due to this shortcoming it is therefore not possible to make any definite conclusions with regard to the effectiveness of CWT compared to other recovery techniques (Coffey *et al.*, 2004:9). Consequently, even though the benefits of using CWT for the psychological recovery of athletes has been proven, more scientific support is needed to support the use of CWT as a recovery modality (Barnett, 2006:789).

As has been mentioned before, PAR is also regarded as a post-exercise recovery technique and will therefore be briefly discussed.

2.6.3 Passive recovery

Some coaches encourage players to rest passively (PAR) after exercise and allow the body to recover without any intervention (Lambert & Van Wyk, 2009:1). PAR generally entails that a participant sits still for the duration of the recovery period (Lattier *et al.*, 2004:510; Monedero & Donne, 2000:594). Tables 2.5 and 2.6 summarise the results of PAR related research.

Table 2.5: Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Coffey <i>et al.</i> (2004)	Treadmill runs to exhaustion at 120% and 90% of peak running speed	DNS	15 min	1	Stood upright confined to an 80cm diameter circle	No significant effect on any performance variables compared to CWT
Connolly <i>et al.</i> (2003a)	Six 15s maximal cycle ergometer sprints at a 5.5 kg workload with 3 min rest between each work bout	DNS	2 min 50 sec	6	Remained stationary on the cycle ergometer	No changes in blood lactate levels compared to AR

°C – Degrees Celsius; **DNS** – Did not specify; **HR** – heart rate; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.5 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
De Nardi <i>et al.</i> (2011:610)	Training session that consisted of soccer-specific running drills, dynamic stretches, performance tests (countermovement jump), repeated sprints (12 x 20m, 20s rest), 5 min shuttle runs (12 km/h), 30 min of low intensity training and small-sided games (4 x 4 min)	DNS	8 min	1	Rested in the shadow	↓ Repeated sprint ability compared to CWI and CWT
De Pauw <i>et al.</i> (2014)	A one hour cycling trial at 55% of W_{max} followed by a 30 min simulated time trial	30 (Climate chamber)	15 min	1	Sat on a comfortable chair	↓ Aerobic cycling power output* ↓ Power output
Delextrat <i>et al.</i> (2013)	One competitive basketball match	20 (Ambient temperature)	30 min	1	Seated	No significant effect on recovery compared to CWI

°C – Degrees Celsius; **DNS** – Did not specify; **HR** – heart rate; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.5 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Elias <i>et al.</i> (2012)	Repeated sprint ability test (6 x 20m, departing every 30s)	DNS	14 min	1	Lying	No effect on restoring static and countermovement jump performance as well as sprint performance (6 x 20m)
Glasgow <i>et al.</i> (2014)	Three DOMS inducing eccentric hamstring curls on a standing hamstring curl machine at 6°	DNS	10 min	1	Seated rest	No significant effect on recovery compared to CWI and CWT
Goodall and Howatson (2008)	Five times 20 drop jumps (0.6m) with 10s rest between each jump and 2 min rest between sets	DNS	12 min	1	Seated	No differences were found between CWI and PAR for knee extensors MVC
Ingram <i>et al.</i> (2009)	Eighty minute simulated team sport exercise and 20m shuttle run test	22	15 min	1	Seated	↓ Isometric muscle strength*

°C – Degree Celsius; **DNS** – Did not specify; **DOMS** – Delayed Onset of Muscle Soreness; **Min** – minutes; **MVC** – Maximal Voluntary Contraction; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.5 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Juliff (2011)	Three netball exercises that consisted of sprints, agility exercises, backward and sideways movements and jumps interspersed by a series of repeated sprints	20	14 min	1	Remained seated with minimal movement	↑ Skin temp No differences in core temp No significant effect on recovery compared to CWT
Lattier <i>et al.</i> (2004)	Three sets of 10 runs each lasting 1 min at an intensity of 120% of MAV with 2 min rest between repetitions	DNS	20 min	1	Remained seated	No improvement in subsequent (1 min of 10 repetitions) uphill, anaerobic running performance

°C – Degree Celsius; **DNS** – Did not specify; **MAV** – Maximal Aerobic Velocity; **Min** – minutes; **MVC** – Maximal Voluntary Contraction; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.5 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Mika <i>et al.</i> (2007)	Three sets of dynamic leg extension and flexion exercises (20-110°) at 50% of MVC with 30s rest between sets	DNS	5 min	1	Lying down in a relaxed position	No significant ↑ in motor unit activation compared to active recovery
Monedero and Donne (2000)	Two simulated 5 km maximal effort cycling tests (T1 and T2) separated by a recovery intervention	DNS	15 min	1	Remained seated on a chair	Not efficient in lactate removal ↓ HR ↑ Mean BL*
Morton (2007)	Four 30s Wingate cycle tests	DNS	30 min	1	Lying stationary on the recovery bed	No effect on the rate of plasma lactate clearance compared to CWT
Peiffer <i>et al.</i> (2009)	Two bouts of 90 min cycling at 12W followed by a 16.1 km time trial in the heat (32°C)	24	20 min	1	Sat passively in the laboratory	No significant differences in work performed between CWI and PAR

°C – Degree Celsius; **DNS** – Did not specify; **Min** – minutes; **MVC** – Maximal Voluntary Contraction; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.5 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Peiffer <i>et al.</i> (2010b)	A 25 min cycling session at 22W followed by a 4-km time trial	35 (Heat chamber)	15 min	1	Seated	No improvement in repeated cycling performance compared to CWI
Pointon and Duffield (2012)	Three sets of two repetitions of a 30 min sprint protocol with tackling on a 20 m running track with 5 intense lower-body tackles separated by 10s every 6 min for a total of 40 tackles	DNS	20 min	1	Seated in the laboratory	No effect on acute recovery of muscle soreness compared to CWI
Pointon <i>et al.</i> (2012)	Two 30 min intermittent sprints – a 15m sprint every minute separated by bouts of jogging and walking	DNS	20 min	1	Seated in the laboratory	↑ MVC activation 24h post-recovery*

°C – Degree Celsius; **DNS** – Did not specify; **HR** – heart rate; **Min** – minutes; **MVC** – Maximal Voluntary Contraction; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.5 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Robey <i>et al.</i> (2009)	Stair climb running (3.6 km, 242 stairs)	DNS	15 min	1	Seated	No significant differences in leg strength between CWT, PAR and stretching
Sayers <i>et al.</i> (2011)	Two 30s maximal intensity Wingate tests	DNS	12 min	1	Seated upright with legs outstretched	No significant effect on fatigue compared to CWT ↓ in anaerobic power* ↓ in average cycling power and total work
Takeda <i>et al.</i> (2014)	Eighty minutes rugby match simulation which consisted of tackles and body contacts	DNS	15 min	1	Seated on a chair	No significant effect of muscle damage blood markers (AST, LDH, CPK, Cre) ↓ Body surface temperature*

AST – Aspartate aminotransferase; **°C** – Degrees Celsius; **CPK** – Serum creatine kinase; **Cre** – Creatinine; **DNS** – Did not specify; **HR** – heart rate; **LDH** – Lactate dehydrogenase; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.5 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the physiological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Tessitore <i>et al.</i> (2007)	A program of 100 min that consisted of a warm up of 15 min, individual, group and team technical drills of 65 min, a circuit of 20 min that consisted of squat jumps, countermovement jumps, bounce jumps and 10m sprints	DNS	20 min	1	Seated	No significant differences in anaerobic performance (squat jump, countermovement jump, bounce jump and 10m sprint)
Vaile <i>et al.</i> (2007)	DOMS induced leg press protocol (5 x 10 eccentric bilateral leg press)	DNS	15 min	1	Seated with minimal movement	No benefit in recovery compared to CWT

°C – Degrees Celsius; DNS – Did not specify; **HR** – heart rate; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

In the majority of studies where PAR was applied athletes remained seated for the duration of the recovery time (De Nardi *et al.*, 2011; De Pauw *et al.*, 2014; Delextrat *et al.*, 2013; Glasgow *et al.*, 2014; Goodall & Howatson, 2008; Ingram *et al.*, 2009; Juliff, 2011; Lattier *et al.*, 2004; Monedero & Donne, 2000; Peiffer *et al.*, 2009; Peiffer *et al.*, 2010b; Pointon & Duffield, 2012; Pointon *et al.*, 2012; Robey *et al.*, 2009; Sayers *et al.*, 2011; Takeda *et al.*, 2014; Tessitore *et al.*, 2007; Vaile *et al.*, 2007), laid down in a supine and relaxed position (Elias *et al.*, 2012; Mika *et al.*, 2007; Morton, 2007), or remained stationary on a cycle ergometer (Connolly *et al.*, 2003a). Athletes in one study had to stand upright confined to an 80cm diameter circle (Coffey *et al.*, 2004) (Table 2.5).

Application time of PAR varied between less than 10 min (De Nardi *et al.*, 2011; Mika *et al.*, 2007) and 10 to 15 min (Coffey *et al.*, 2004; Connolly *et al.*, 2003a; De Pauw *et al.*, 2014; Elias *et al.*, 2012; Glasgow *et al.*, 2014; Goodall & Howatson, 2008; Ingram *et al.*, 2009; Juliff, 2011; Monedero & Donne, 2000; Peiffer *et al.*, 2010b; Robey *et al.*, 2009; Sayers *et al.*, 2011; Takeda *et al.*, 2014; Vaile *et al.*, 2007). However, a few researchers applied PAR for 20 min (Lattier *et al.*, 2004; Peiffer *et al.*, 2009; Pointon & Duffield, 2012; Pointon *et al.*, 2012; Tessitore *et al.*, 2007) or even 30 min (Delextrat *et al.*, 2013; Morton, 2007).

Researchers found no significant differences ($p > 0.05$) in muscle contractile properties and perceived muscle soreness between PAR and active recovery (AR), post-soccer training. However, a significant ($p < 0.05$) change was observed in the PAR group (Rey *et al.*, 2012:3085). Furthermore, no significant differences ($p > 0.05$) in squat jump, countermovement jump, bounce jumping, and 10-m sprint performance were found between a PAR group (sitting for 20 min) and other groups of young elite soccer players who performed dry-aerobic or water-aerobic exercises or electro-stimulation, respectively (Tessitore *et al.*, 2007:745, 747). Mika *et al.* (2007:476, 477) assessed the influence of PAR (lying down for 5 min), AR (light pedalling on a cycle ergometer for 5 min at 60 rpm) and stretching (isometric contractions for a total of 5 min) on muscle relaxation of ten healthy males after dynamic exercises. They reported no significant increases ($p > 0.05$) in motor unit activation, but a significant increase ($p < 0.05$) was noted after active recovery. Other researchers reported a significant decrease ($p < 0.04$) in aerobic cycling power output after an one hour-long cycling trial (De Pauw *et al.*, 2014:243) and a significant decrease ($p < 0.05$) in isometric muscle strength after an 80 min simulated team sport exercise when PAR was used as a recovery technique (Ingram *et al.*, 2009:419). In addition

researchers found a significant increase ($p < 0.01$) in mean blood lactate concentrations after two simulated 5 km maximal effort cycling tests (Monedero & Donne, 2000:595) and significant increases ($p = 0.01$) in maximal voluntary contraction activation 24h post-recovery after 2 x 30 min intermittent sprints in participants who used PAR for recovery (Pointon *et al.*, 2012:2488). PAR also led to a significant decrease ($p < 0.00$) in anaerobic power after 2 x 30s maximal Wingate tests (Sayers *et al.*, 2011:297) as well as a significant decrease ($p < 0.05$) in body surface temperature after an 80 min simulated rugby match (Takeda *et al.*, 2014:619). The next section will deal with the possible psychological recovery benefits of PAR (Table 2.6).

Table 2.6: Summary of studies that investigated the post-exercise effects of PAR protocols on the psychological recovery of athletes

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Brophy-Williams <i>et al.</i> (2011)	Eight high intensity treadmill running intervals of 3 minutes at a velocity of 90% of VO _{2max}	23	15 min	1	Seated	↑ Perceived recovery score* (Total Quality Recovery Perception scale)
De Nardi <i>et al.</i> (2011:610)	Training session that consisted of soccer-specific running drills, dynamic stretches, performance tests (countermovement jump), repeated sprints (12 x 20m, 20s rest), 5 min shuttle runs (12 km/h), 30 min of low intensity training and small-sided games (4 x 4 min)	DNS	8 min	1	Rested in the shadow	No significant decrease in levels of perceived fatigue compared to CWI
Elias <i>et al.</i> (2012)	Repeated sprint ability test (6 x 20m, departing every 30s)	DNS	14 min	1	Lying	No effect on muscle soreness No effect on perceived fatigue

°C – Degrees Celsius; **DNS** – Did not specify; **HR** – heart rate; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.6 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the psychological recovery of athletes post-exercise

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Gill <i>et al.</i> (2006)	Elite rugby players were monitored over four matches, each followed by a recovery session	DNS	9 min	1	Seated on a bench	Not beneficial in reducing perception of fatigue compared to CWT
Hauswirth <i>et al.</i> (2011)	Three simulated trail treadmill runs of 15 min each, designed to induce muscle damage followed by recovery interventions at 1h, 24h and 48h post-exercise	24	30 min	1	Seated in an arm chair	No significant changes in pain or perceived tiredness compared to WBC
Ingram <i>et al.</i> (2009)	Eighty minute simulated team sport exercise and 20m shuttle run test	22	15 min	1	Seated	No significant effect on leg soreness compared to CWI or CWT

°C – Degrees Celsius; **DNS** – Did not specify; **Min** – minutes; **s** – seconds; **Temp.** – temperature; **WBC** – Whole-body Cryotherapy; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.6 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the psychological recovery of athletes post-exercise

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Lane and Wenger (2004)	4 x 18 min cycling sessions on a cycle ergometer separated by 24 hours	DNS	15 min	1	Sat passively	Subjects reported that their legs felt heavy and stiff
Rey <i>et al.</i> (2012)	Soccer training of 45 min that consisted of maximal exercises (20 x 30m with a 30s rest period) for 15 min followed by a 30 min group specific aerobic drill (4 x 4 min of 5 a side game)	DNS	20 min	1	Sat on a bench	↑ Perceived muscle soreness*

°C – Degrees Celsius; **DNS** – Did not specify; **HR** – heart rate; **Min** – minutes; **s** – seconds; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

Table 2.6 (cont.): Summary of studies that investigated the post-exercise effects of PAR protocols on the psychological recovery of athletes post-exercise

Authors	Exercise Protocol	Room Temp (°C)	Application time	Repeats	Position	Main findings
Tessitore <i>et al.</i> (2007)	A program of 100 min that consisted of a-warm up of 15 min, individual, group and team technical drills of 65 min, a circuit of 20 min that consisted of squat jumps, countermovement jumps, bounce jumps and 10m sprints	DNS	20 min	1	Seated	↑ Mean subjective ratings* No significant differences in anaerobic performance (squat jump, countermovement jump, bounce jump and 10m sprint)

°C – Degrees Celsius; **DNS** – Did not specify; **Min** – minutes; **s** – seconds; **Temp.** – temperature; ↓ - Decreased/lower; ↑ - Increased/better; * - $p \leq 0.05$

From Table 2.6 it is clear that for the majority of studies where PAR was applied athletes remained seated for the duration of the recovery period (Brophy-Williams *et al.*, 2011; De Nardi *et al.*, 2011; Gill *et al.*, 2006; Hausswirth *et al.*, 2011; Ingram *et al.*, 2009; Rey *et al.*, 2012; Tessitore *et al.*, 2007), or laid down in a supine and relaxed position (Elias *et al.*, 2012). Application times for PAR varied between less than 10 min (De Nardi *et al.*, 2011; Gill *et al.*, 2006) and 10 to 15 min (Brophy-Williams *et al.*, 2011; Elias *et al.*, 2012; Ingram *et al.*, 2009). However, a few researchers applied PAR for 20 min (Rey *et al.*, 2012; Tessitore *et al.*, 2007) or 30 min (Hausswirth *et al.*, 2011).

Various researchers compared the possible benefits of PAR to that of other post-recovery techniques. In this regard Rey *et al.* (2012:3085) observed a significant increase ($p < 0.05$) in perceived muscle soreness in professional soccer players who were subjected to PAR (20 min sitting on a bench) 24h after specific soccer training compared to players that were subjected to AR (12 min of submaximal running and 8 min of static stretching). Another study reported no significant mean subjective ratings for perceived exertion in the PAR group (sitting for 20 min) compared to groups of young elite soccer players who performed dry-aerobic or water-aerobic exercises or electro stimulation, respectively (Tessitore *et al.*, 2007:747, 748). Hausswirth *et al.* (2011:e27749) observed that neither pain nor perceived tiredness of nine well-trained runners was reduced by PAR (seated for 30 min) 48h after exercise when compared to the effects of whole-body cryotherapy (WBC) and far-infrared therapy (FIR). Moreover, another study reported that cyclists' legs felt heavy and stiff between cycling trials when PAR was used as a recovery technique (Lane & Wenger, 2004:859). On the other hand significant decreases ($p = 0.00$) in the perceived recovery score were reported after high intensity treadmill running following PAR (Brophy-Williams *et al.*, 2011:668).

Despite various findings with regard to the effects of PAR on the recovery of athletes further investigations are needed, especially to understand the psychological benefits of the last-mentioned recovery technique (Tessitore *et al.*, 2007:749). Furthermore, some researchers do not recommend the use of PAR as a post-exercise recovery technique, but rather light, active exercises, such as cycling with minimal resistance (Mika *et al.*, 2007:477), which casts a shadow of doubt on efficacy of PAR as a recovery technique.

Overall, above-mentioned findings show that the execution of some sort of recovery technique immediately post high-intensity exercise may be beneficial for the physiological and psychological recovery of athletes. Improved recovery may help to enhance exercise sessions and match performances (Lane & Wenger, 2004:859). However, more research is needed to verify the benefits of different recovery techniques for the physiological and psychological recovery of especially team sport participants.

In order for researchers to determine the efficacy of different recovery techniques it is important to measure and monitor different recovery parameters or indicators frequently (Kellmann, 2010:98, 101; Kenttä *et al.*, 2006:252). In this regard psychometric instruments seem to provide quick information (sometimes within minutes) on the recovery of athletes when compared to physiological measurements such as blood analyses which may take much longer (Kellmann, 2002b:38). Therefore, sport and exercise psychologists rely upon valid psychological measuring instruments to determine the psychological state of athletes (Terry *et al.*, 2003b:231).

2.7 Psychometric instruments used in the assessment of stress and recovery in sport

Psychometric monitoring instruments allow researchers to assess mood, the need for recovery and current life circumstances of players (Kenttä *et al.*, 2006:251). Certain self-report questionnaires may also provide information about the stress-recovery balance of athletes (Barnett, 2006:786).

2.7.1 Daily Analyses of Life Demands for Athletes questionnaire (DALDA)

DALDA (Rushall, 1990) has been used in several studies during periods of intensified training (Coutts *et al.*, 2007b:375; Halson *et al.*, 2002:947; Robson-Ansley *et al.*, 2007:353) and is designed to assess the sport-specific stress of training (Rushall, 1990). DALDA is divided into two parts: Part A evaluates the “sources of life stress” and Part B the “symptoms of stress” (Robson-Ansley *et al.*, 2009:3). The questionnaire is normally completed by athletes on a daily basis, and day-to-day responses are then graphically plotted (Robson-Ansley *et al.*, 2007:353). Peaks in the sum of the “worse-than-normal” responses that remain elevated for several days may be an indication of overreaching and the risk of developing underperformance syndrome (Rushall, 1990). DALDA may serve as a useful daily tool to make athletes aware of symptoms as well as physical and psychological stressors from both the sporting and non-sporting environment (Robson-Ansley *et al.*, 2009:3). In this regard Halson *et al.* (2002:951, 953) reported a change in DALDA scores after 2 weeks of high intensity training which were

associated with the accumulation of fatigue and a decrease in peak power and 40km time trial performance.

DALDA is regarded to be a practical and effective, subjective questionnaire to indicate changes in training-related stress (Robson-Ansley *et al.*, 2009:9) and for monitoring fatigue, stress and recovery (Coutts *et al.*, 2007a:378). The validity of DALDA was established through content validity procedures after an item pool of 13 stresses and 44 symptoms was developed (Rushall, 1981, 1987). The reliability of this tool was determined through test-retest procedures on 52 athletes who completed the questionnaire on 5 separate occasions, each at least 14 days apart. Items that were not reliable for 80 percent of the time were deleted from the item pools. The validity and reliability screening procedure reduced the sources of stress to 9 areas and the symptoms of stress to 25 items. Thus a valid and reliable self-report inventory was established for use in sporting environments (Rushall, 1987). Although these results may suggest that DALDA is a better questionnaire for monitoring training stress in athletes compared to the POMS, DALDA is rarely used in overtraining studies (Lamberts, 2009:9).

Another frequently used questionnaire used to monitor athletes is The Profile of Mood States (POMS) questionnaire.

2.7.2 The Profile of Mood States (POMS)

The POMS (McNair *et al.*, 1971) is a 65-item inventory that assesses six dimensions of the mood construct, namely: anger, confusion, depression, fatigue, tension and vigour (Terry *et al.*, 2003a:126). The maladaptation to an imposed training stress is often associated with changes in disposition, therefore, the POMS has been used extensively to monitor stress on a daily basis (Robson-Ansley *et al.*, 2009:2). The POMS is useful in detecting mood fluctuations during exercise and appear to measure mood subcomponents, which are differentially responsive to diverse characteristics of exercise settings (Kellmann, 2010:98). POMS is normally administered with instructions to respond on the basis of feelings experienced in the “last week including today”, yielding mood measures that exhibit test-retest reliabilities of between 0.56 and 0.74 (McNair *et al.*, 1992). Psychological states measured by the POMS revealed low validity values (0.16–0.33) compared to the measures of traits which showed higher validity values (0.80–0.90) (McNair *et al.*, 1992).

Research suggests that there is a positive relationship between sport performance and mood state changes (Ke-tien, 2012:1224). Furthermore, the POMS have also been used to identify psychological stress markers during strenuous cardiovascular endurance training (Ke-tien, 2012:1219). For example, participants who incorporated low-intensity exercise into their recovery regimens showed significantly lower ($p < 0.05$) POMS scores than those who did not (Ke-tien, 2012:1224). The researcher therefore concluded that moderate exercise enhances relaxation and decreases psychological stress (Ke-tien, 2012:1224). For this reason, regular use of the POMS may help detect under-recovery, thereby preventing staleness and unwanted rest for extended periods (Kenttä *et al.*, 2006:252).

Consequently, the POMS is regarded to be a valid monitoring instrument, with a dose-response relationship between observed scores and training load (Kenttä *et al.*, 2006:246). However, a shortcoming of the POMS is that it only focuses on mood state responses to training (Kenttä *et al.*, 2006:246) and is only available in one language (English). These shortcomings gave rise to the Stellenbosch Mood Scale (STEMS) which is a dual-language (Afrikaans and English) version of the POMS.

2.7.3 The Stellenbosch Mood Scale (STEMS)

The STEMS is a measure of mood descriptors in both Afrikaans and English for use in the South African context (Terry *et al.*, 2003b:232). The STEMS is a derived and a shortened version of the original POMS (McNair *et al.*, 1971). The STEMS measures the same six subscales as the original POMS (Tension, Depression, Anger, Vigour, Fatigue and Confusion), with four items contributing to each subscale (Grobbelaar *et al.*, 2011:654). The STEMS shows acceptable psychometric properties and is suitable for use with Afrikaans or English speakers (Terry *et al.*, 2003b:241). Acceptable Cronbach alpha coefficients (ranging from 0.65 to 0.87) were observed by Grobbelaar *et al.* (2010:45) for a group of university-level rugby players with a mean age of 22.26 ± 13.9 years. Terry *et al.* (2003b:237) also found acceptable internal consistencies for all six mood scales of the STEMS, with alpha coefficient values of 0.7 and higher. Another advantage of the STEMS is that it is very brief, making it a useful instrument when limited time is available (Nel, 2012:38).

Another instrument, The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport), focuses on the frequency of stress-recovery activities (Kenttä *et al.*, 2006:246).

2.7.4 The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport)

The RESTQ-Sport is a valid and reliable instrument for measuring the regularity of psychological stress along with recovery-associated activities (Kellmann & Kallus, 2001:5). In this regard the RESTQ-sport was used successfully to monitor perceived stress and recovery states in adolescent (Kellmann *et al.*, 2001:151) and adult athletes (Purge *et al.*, 2006:1075). Other studies also used the RESTQ-sport to measure the effect of high training load on perceived stress and recovery (Bouget *et al.*, 2006:1297; Coutts & Reaburn, 2008:904), to monitor sport performance (Jürimäe *et al.*, 2002:520; Kalda *et al.*, 2004:12; Kellmann & Günther, 2000:676; Martinent & Decret, 2012:76; Purge *et al.*, 2005:375), to monitor individuals and/or groups during micro-cycles (Kellmann *et al.*, 2001:151; Kellmann & Günther, 2000:676) and over an entire season (Bresciani *et al.*, 2010:377; Ferger, 1998:131). Studies have also examined changes in RESTQ-sport measures of rowers and triathletes during strenuous training (Coutts *et al.*, 2007a:372; Kellmann & Kallus, 2001:1).

The RESTQ-Sport consists of 19 scales, which can be grouped into the following four major subscales: General Stress, General Recovery, Sport-Specific Stress and Sport-Specific Recovery Activities. The general stress subscales assess subjective strain, including: general stress, emotional stress, social stress, conflicts/pressure, fatigue, lack of energy, and physical complaints. Recovery subscales include: success, social recovery, physical recovery, general well-being, and sleep quality. Sport-specific subscales include stress (fitness/injury, burnout/emotional exhaustion, and disturbed breaks) and recovery activities (fitness/being in shape, burnout/personal accomplishment, self-regulation and self-efficacy) (Kellmann & Kallus, 2001:5). The RESTQ-Sport assesses potentially stressful and restful events and the subjective consequences of these events regarding previous three days/nights. For shorter measurement intervals, the test-retest reliability is higher. Acceptable test-retest reliability over a 24-hour period ($r > 0.79$), internal consistency (Cronbach alphas > 0.70 for most subscales) and construct validity have been shown (Kellmann & Kallus, 2001:29, 39, 40).

Various studies reported high correlations between the RESTQ-Sport and the POMS-scales (Kellmann & Kallus, 2001:8). For example, in a study of forty-one male university rugby players (mean age: 21.87 ± 1.39 years) acceptable Cronbach alphas of between 0.58 and 0.88 were calculated for 15 of the 19 subscales (Grobbelaar *et al.*, 2010:44). Furthermore, the advantages of the RESTQ-Sport are that it follows a systematic multi-level approach, it allows practitioners

and sport scientists to provide recommendations that are specific to certain intervention strategies and it enables practitioners and sport scientists to plan recovery strategies and techniques (Nel, 2012:40). Regular monitoring of stress and recovery may enable coaches to detect overtraining in its early stages (González-Boto *et al.*, 2008a:19).

A study by Brink *et al.* (2010:809) examined psychosocial stress-recovery states of elite youth soccer players by using the Dutch version of the RESTQ-Sport. The testing protocol also included training and match duration logs as well as session ratings of perceived exertion for two competitive seasons (Brink *et al.*, 2010:809). Due to the conclusion that psychosocial stress and recovery were related to the occurrence of illness and injuries, researchers confirmed that individual monitoring of stress and recovery may provide soccer players with useful information to prevent illness and injuries (Brink *et al.*, 2010:809). This is especially important in view of the fact that increased training volume led to an increase in somatic components of stress (fatigue, somatic complaints, fitness/injury) and a decrease in recovery factors (success, social relaxation, sleep quality, being in shape and self-efficacy) in competitive male rowers (Jürimäe *et al.*, 2004:336). In another study researchers indicated that increases in highly trained rowers' RESTQ-sport recovery-stress states negatively affected rowing performance (Purge *et al.*, 2005:376).

Other researchers used the RESTQ-Sport to monitor rugby players' stress and recovery during matches and reported that fatigue, lack of energy, and success were significantly lower during the later compared to the earlier stages of competition (King *et al.*, 2010a:223). They also found that social recovery decreased as the season progressed and recommended that pre-match activities should be implemented to facilitate team recovery and aid in reducing stress stimuli (King *et al.*, 2010a:223). Interestingly, a study of elite student rugby players showed that experienced players revealed the least favourable total recovery-stress, general and sport-specific stress major scale and subscale scores whereas players who had limited experience showed the most favourable scores (Grobbelaar *et al.*, 2010:42, 52, 53). Hartwig *et al.* (2009:1088, 1090) also revealed that adolescent rugby players, who achieved the highest training volume during the in-season, were those who coped better with the RESTQ-Sport stress-recovery state. Coutts *et al.* (2007b:125) indicated that players' recovery-stress state was impaired by an increase in training load, which improved significantly ($p < 0.05$) after a taper period. Coutts and Reaburn (2008:904) also observed that rugby players experienced a decrease in the physical recovery

subscale and an increase in the fatigue scale, but no change in the physical complaints of injuries scales (RESTQ-Sport) after a period of intensified training.

The above-mentioned findings together with the results of Davis *et al.* (2006:18) suggest that athletes who show lower scores for stress and higher scores in recovery-related items will be able to maintain a higher training quality and better performance. Therefore, it is critical to monitor factors that influence the stress-recovery balance in order to enhance the recovery process (Kellmann, 2010:98, 101; Kenttä *et al.*, 2006:252) and maintain performance (Nel, 2012:57).

2.8 Conclusion

From the discussion above it is clear that rugby imposes high physiological and psychological demands on players, which are further exacerbated by the demanding competition regime that players face, the short recovery durations between matches and intense training sessions. These factors highlight the need for and importance of optimal recovery strategies that will facilitate recovery, and enhance training adaptations as well as match performances.

In view of this background, the first aim of the literature review was to describe the physical, physiological and psychological demands of rugby, whereas the second aim was to discuss the characteristics and causes of overtraining and burnout. The third aim was to define the term recovery and explain the need for recovery in sport. The fourth aim was to describe CWI, CWT and PAR as well as discuss findings with regard to the physiological and psychological effects of these recovery techniques on especially sport participants. Lastly, the fifth aim of the review was to discuss different psychometric instruments used in the assessment of stress and recovery in sport participants.

Collectively, the author found that rugby players have to be physically fit to adapt to high game intensities. Players need to be strong, fast, and powerful in order to gain possession of the ball, as well as agile, flexible and have good aerobic endurance. Backs need to perform tackles and focus more on running at high speeds, whereas forwards take part in scrums in addition to running and tackling. Rugby requires a high level of aerobic conditioning to facilitate the recovery between high-intensity bouts during which energy is derived from anaerobic sources. Therefore it can be concluded that players will rely on significant energy utilisation from all energy systems. However, evidence suggests that the anaerobic glycolytic pathway plays an important role in all

positions, particularly the forwards. Furthermore, the aerobic system is important for rugby players in all positions.

Apart from the physiological demands of rugby training and matches, players also have to be able to handle the psychological stressors that are related to rugby participation. Rugby players have to cope with setbacks and pressures on and off the field. Psychological stress in rugby can be attributed to the ever-growing pressure to win, the fear of failure, goals which are often set too high, lack of confidence, injuries, strenuous training sessions and inadequate rest. These stressors may negatively affect players' ability to control emotion and anxiety during training and games, to cope with victories and losses, as well as to achieve personal goals and focus. The increased stress demands of rugby and insufficient recovery will lead to increased stress levels and a decline in performance. Rugby players need to cope with psychological stress by reaching an adequate recovery state, which will ultimately enhance performance. However, up until now most researchers have only investigated the physical demands of rugby players, thereby neglecting the psychological demands that these players have to deal and cope with.

High psychological demands may lead to an imbalance between training stress and recovery which over time may cause overtraining and burnout. Overtraining and burnout are characterised by performance declines, psychological and hormonal disturbances, loss of appetite and an increased vulnerability to injuries. Other symptoms also include amongst others a depressed mood, general apathy, decreased self-esteem, irritability and disturbed sleep. Continued overtraining without adequate rest may lead to burnout, which may cause players to withdraw themselves on a physical, social and emotional level from the sporting activity they formerly enjoyed. In order to control factors that affect and contribute to overtraining, resting or reduced training for a period of time (weeks or months) or an improvement in the quality of recovery is necessary. It is therefore important to implement effective recovery strategies especially during periods when training loads are increased and athletes experience fatigue.

Recovery can be defined in different ways, but from a rugby perspective, it is considered to be the point at which a player is able to train without constraints of sore muscles or an increased risk of injury (Lambert & Van Wyk, 2009:5), and involves that the body returns from a fatigue state towards its normal physiological and performance baseline. Fast and efficient recovery is therefore important for high-intensity competitive athletes such as rugby players. Furthermore,

adequate recovery will maintain optimal performance and enhance both physiological and psychological recovery.

From the literature it is evident that CWI which is one of the best known recovery techniques benefits athletes' post-exercise recovery due to the physiological and psychological changes that it brings about. With regard to physiological changes researchers found that CWI post-exercise significantly ($p < 0.05$) reduced skin temperature, heart rate, thermal strain, significantly ($p < 0.01$) increased blood lactate removal and maintained high-intensity performance. These benefits occurred when CWI temperatures of between 8 and 15°C were used for durations of between 4 and 20 min. However, a few non-significant findings were found for 14 and 15 min CWI exposures, which included a decrease ($p > 0.05$) in blood lactate levels (at 11°C), non-significant differences in total work completed between two cycling trials (at 15°C), a non-significant decrease ($p > 0.5$) in isometric leg extension and flexion strength (at 10°C) as well as a non-significant increase ($p > 0.05$) in the return to baseline sprint performance after 80 min of a rugby simulated team sport exercise. Furthermore, CWI (10 min at 15°C) did not reduce the perception of effort or restored muscle damage after a rugby game.

Research on the psychological benefits of CWI post-exercise revealed that CWI significantly reduced perceived muscle soreness, increased the perception of recovery and reduced the perception of fatigue. These changes were observed when CWI temperatures of between 10 and 15°C were used and the application times were between 5 and 15 min. In contrast, some researchers found CWI to be inefficient in significantly reducing the perception of muscle soreness following competitive simulation games. Despite findings which suggest that CWI protocol temperatures of between 8 and 15 °C for durations of between 4 and 20 min seem to be the most effective in bringing about positive changes in the psychological and physiological recovery of athletes, wide variations in results, CWI temperatures and durations make it difficult to fix specific CWI protocol guidelines for athletes. More research is therefore required to establish guidelines for the most effective CWI protocols for use in athletes and especially team sport participants such as rugby players.

Findings with regard to the physiological effect of CWT on athletes are very conflicting and limited, although some found that CWT significantly ($p < 0.00$) decreased plasma lactate concentration and increased blood lactate removal after high intensity exercise. These benefits

were derived when CWT temperatures of between 36 and 40°C as well as 12 and 23°C were used for total exposure times of between 12 and 25 min. Furthermore, some researchers observed significant ($p < 0.00$) decreases in the perception of fatigue, the perception of muscle soreness and muscle pain ($p < 0.01$), as well as a significant ($p < 0.00$) decrease in ratings of fatigue due to CWT after exercise. CWT exposures of less than 10 min caused a non-significant decrease ($p > 0.05$) in blood lactate concentration and heart rate, no significant difference ($p > 0.05$) in repeated sprint performance after a repeated sprint test as well as a non-significant decrease ($p > 0.05$) in the perception of fatigue and muscle soreness after exercise-induced muscle damage. Exposures of more than 10 min caused a non-significant difference ($p > 0.05$) in squat performance after exercise-induced muscle damage, strength performance after stair climb running, a non-significant increase ($p > 0.05$) in return to baseline values as well as a non-significant decrease ($p > 0.05$) in the perception of fatigue, discomfort and stress after exhaustive treadmill runs.

Exposure temperatures ranged between 38 and 40°C as well as 8 and 15°C and total exposure times between 9 and 24 min for the CWT protocols that obtained the last-mentioned psychological benefits. Similar to CWI-related studies, CWT protocol application times varied considerably between studies with total application times that ranged from 6 to 25 min and consisted of 1 to 2 min of CWI and 2 min of hot water immersion. Water temperatures for immersions in cold water varied from 8 to 15°C and for hot water from 28 to 42°C. However, existing research suggests that CWT protocols are successful in causing significant psychological changes, specifically in perceived fatigue and muscle soreness of athletes, post-exercise.

Most research findings showed that PAR was insufficient in restoring rugby players' recovery after match-play, and that active recovery was significantly ($p < 0.05$) more effective in causing post-match, psychological recovery. Furthermore, neither short- nor long-term PAR was effective in causing recovery in athletes who participated in consecutive training sessions over a prolonged period of time. In general, researchers made use of PAR protocols that required participants to either lie supine on a bed or to remain seated with minimal movement. The duration of most PAR protocols varied between 8 and 30 min. However, a PAR protocol that caused significant ($p < 0.05$) improvements in the perceived muscle soreness of athletes, entailed that participants had to remain seated for 20 min. Despite these results, researchers do suggest

that light, active exercises, such as cycling with minimal resistance rather be used as a post-exercise recovery technique instead of PAR.

Overall the above-mentioned findings support the use of CWI and CWT as the most popular post-exercise recovery techniques for team and individual sport participants. More than enough studies showed that both these techniques benefit athletes with regard to physiological and psychological recovery for optimal performance. However, more research is needed to especially investigate the psychological recovery benefits of these techniques for rugby players.

As has been shown, researchers also need to consider the reliability, validity and usefulness of psychometric instruments that can be used to evaluate athletes' psychological components and profile after the application of different recovery techniques. Although, research suggests that the DALDA, POMS, STEMS and RESTQ-Sport are all instruments that can be used in this regard, the RESTQ-Sport is the only valid and reliable instrument for measuring the regularity of both psychological stress and recovery-associated activities. An instrument that allows researchers, sport practitioners and athletes to monitor factors that influence the stress-recovery balance may enable these groups of people to enhance the recovery process and maintain performance. However, there is a shortage of scientific data that verifies the psychological benefits of different recovery techniques in elite athletes by making use of the RESTQ-Sport. Therefore, it can be recommended that in the future researchers should focus more on the possible effects of CWI, CWT and PAR as viable recovery modalities on the RESTQ-Sport subscale results of especially team sport participants such as rugby players.

Until now the use of a wide variety of CWI, CWT and PAR protocols and guidelines as well as exercise modalities have made it difficult to determine the most efficient protocols for the physiological and psychological recovery of athletes. Another shortcoming of current research in this area is that researchers only focus on the overall effects of these recovery techniques instead of considering each individual athlete's unique responses to a specific recovery technique. Small increases in an individual athlete's responses to a recovery technique may have a significant positive impact on performance, which cannot be disregarded. The absence of a control group; small group sizes and short observation periods over which possible effects of recovery techniques can be evaluated are other shortcomings in current research which also need to be

addressed. Despite these shortcomings, current findings do suggest that especially CWI and CWT have the potential to act as effective post-exercise recovery techniques for athletes.

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CHAPTER 3

3. The 48-hour post-exercise effects of passive recovery and cold water immersion on the subscales of the Recovery-Stress Questionnaire in rugby players

This article will be submitted for publication in the *International Journal of Sport and Exercise Psychology*. This article is hereby included according to the specific prescriptions of the journal. Although not in accordance with the guidelines of the journal, tables were included in the text to make the article easier to read and understand. Furthermore, the line spacing of the article was set at one and a half lines and the first line of each paragraph not indented as to conform to the rest of the dissertation's layout. The instructions for authors are included as Appendix E: Guidelines for authors: International Journal of Sport and Exercise Psychology.

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THE 48-HOUR POST-EXERCISE EFFECTS OF PASSIVE RECOVERY AND COLD WATER IMMERSION ON THE SUBSCALES OF THE RECOVERY-STRESS QUESTIONNAIRE IN RUGBY PLAYERS

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Abstract

The aim of this study was to determine the differences in the 48-hour post-recovery effects of passive recovery (PAR) and cold water immersion (CWI) on the subscales of the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) in university-level rugby players. The RESTQ-Sport was completed by u/21 rugby players of a South African university (n = 23), in the morning before the high-intensity fitness session of 15 minutes, and again 48 hours thereafter. The experimental group completed 20 minutes of CWI, while the control group recovered passively for 20 minutes. PAR caused statistically and large practically significant decreases in conflicts/pressure, success, being in shape and self-regulation while social recovery, general well-being, injury, sport-specific stress and recovery revealed large practically significant decreases. Only self-efficacy showed a medium practically significant decrease, while general stress and physical recovery revealed a large practically significant increase. CWI caused statistically and large practically significant decreases in success, general, social, physical recovery, injury, being in shape, self-efficacy, self-regulation, sport-specific stress and recovery. On the other hand general stress, social stress, disturbed breaks and personal accomplishment all revealed medium practically significant decreases over the same time period. However, the analysis of covariance that determined inter-group changes between groups revealed that only sport-specific recovery and self-efficacy showed a more pronounced significant decrease in the CWI-group compared to the PAR group. Therefore, results of the study suggest that CWI was more beneficial in enhancing 48-h recovery RESTQ-Sport responses in a group of rugby players, compared to PAR.

Keywords: passive recovery; cold water immersion; psychological recovery; rugby; Recovery-Stress Questionnaire

Introduction

Optimal recovery from training is important for rugby players to cope with psychological stress and to enhance both physiological and psychological recovery (Suzuki et al., 2004; Van Wyk & Lambert, 2009) in order to obtain better performances in subsequent training sessions and competitions (Gill, Beaven, & Cook, 2006). The need for recovery strategies in players' training and competition regimes (De Nardi, La Torre, Barassi, Ricci, & Banfi, 2011; Spencer et al., 2005) is accentuated by the fact that rugby is an intense team sport with high physiological and psychological demands (Gill et al., 2006). However, players will only know if a certain recovery strategy is effective if the recovery process is assessed by making use of a psychometric measurement instrument such as the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) (Kellmann, 2010; Kentt , Hassm n, & Raglin, 2006). Advantages of the RESTQ-Sport include the following: it follows a systematic multi-level approach; it allows practitioners and sport scientists to provide recommendations that are specific to certain intervention strategies and results can be used to plan recovery strategies and techniques (Nel, 2012). Furthermore, the RESTQ-Sport does not only assess potentially stressful and restful events, but also the subjective consequences of these events on both the physiological and psychological components of athletes during the three days/nights prior to testing (Kellmann & Kallus, 2001). This is important as most studies have only focussed on the physiological benefits of recovery techniques in the past and often ignored the psychological benefits of these techniques (Stacey, Gibala, Martin Ginis, & Timmons, 2010). The importance of research that investigates the psychological benefits of different recovery techniques is highlighted by the fact that physiological and psychological responses to recovery techniques are interrelated (Stacey et al., 2010).

Although more than sixteen recovery techniques can currently be identified from literature, passive recovery (PAR) and cold water immersion (CWI) are currently being used as primary techniques (Barnett, 2006; Calder, 2000; Lambert & Van Wyk, 2009). CWI involves immersion of a body part or the whole body (excluding the head and neck) in water with a temperature of $\leq 15^{\circ}\text{C}$ for 8 to 15 minutes at a time (Duffield, Murphy, Kellett, & Reid, 2014; Vaile et al., 2011). CWI is commonly used for the treatment of inflammation, redistribution of blood flow

(Vaile, Halson, Gill, & Dawson, 2008b), to decrease ($p < .05$) body temperature and heart rate significantly (Vaile et al., 2008b), and also the perception of muscle soreness post-exercise (Ascensão, Leite, Rebelo, Magalhães, & Magalhães, 2011). Some studies found significant physiological changes following CWI post-exercise such as an increase in blood lactate removal, and a decrease in thermal strain (De Pauw, Roelands, Vanparijs, & Meeusen, 2014), heart rate (Duffield et al., 2014), and rectal temperature (Peiffer, Abbiss, Watson, Nosaka & Laursen, 2010), as well as an increase in the acute recovery of maximal voluntary muscle contractions and voluntary activation (Pointon, Duffield, Cannon, & Marino, 2012). Regarding the psychological benefits of recovery techniques, research suggests that CWI can reduce the perception of fatigue (De Nardi et al., 2011; Elias et al., 2012), and muscle pain (Vaile et al., 2008b) as well as increase the perception of recovery after exercise (Bahnert, Norton, & Lock., 2013; Delextrat, Calleja-González, Hippocrate, & Clarke, 2013).

Another popular recovery technique that is often used in sport is PAR which requires players to rest passively after exercise and to recover without any intervention (Lambert & Van Wyk, 2009) by sitting still for the duration of the recovery period (Lattier, Millet, Martin, & Martin, 2004; Monedero & Donne, 2000). Participants who used PAR as a recovery technique after exercise, experienced a significant decrease ($p < .04$) in aerobic cycling power output after a one hour cycling trial (De Pauw et al., 2014) and a significant decrease ($p < .05$) in isometric muscle strength after an 80 minute simulated team sport exercise (Ingram, Dawson, Goodman, Wallman, & Beilby, 2009). A significant decrease ($p < .00$) in anaerobic power after 2 x 30 seconds maximal Wingate tests (Sayers, Calder, & Sanders., 2011) and a significant decrease ($p < .05$) in body surface temperature after an 80 minute simulated rugby match due to post-exercise PAR were also reported (Takeda et al., 2014:619). Regarding the psychological effects of post-exercise PAR, participants experienced a significant increase ($p = .05$) in perceived muscle soreness (Rey, Lago-Peñas, Casáis, & Lago-Ballesteros, 2012), significantly higher ($p < .01$) mean subjective ratings of perceived exertion (Tessitore, Meeusen, Cortis, & Capranica, 2007) and a non-significant ($p > .05$) increase in perceived muscle pain and tiredness (Hauswirth et al., 2011).

Various researchers have compared the possible benefits of CWI and PAR for athletes post-exercise. In this regard Pointon and Duffield (2012) examined the effects of CWI after a simulated collision sport exercise in male rugby players. CWI of 20 minutes significantly

improved perceptions of muscle soreness ($p = .05$) 2 hours after execution of the collision-based exercise (2 x 30-min intermittent sprint exercise with either tackling or no tackling) compared to PAR (Pointon & Duffield, 2012). The same researchers found no significant differences ($p > .05$) between conditions at any other time point. However tackling exercises followed by CWI and PAR resulted in significant increases ($p < .05$) in ratings of perceived exertion (RPE) compared to the no-tackling exercises (Pointon and Duffield, 2012). De Nardi et al. (2011) found that CWI (15°C for 8 minutes, immersed up to the iliac spine level) during a week of training resulted in significantly ($p = .02$) lower levels of perceived fatigue compared to PAR (resting for 8 minutes) in young, male soccer players. In addition, CWI (15°C for 15 minutes) performed immediately or 3 hours after high intensity exercise resulted in a significantly higher ($p = .00$) Total Quality Recovery Perception (TQRP) scale perceived recovery score in eight trained, male athletes, compared to PAR (Brophy-Williams, Landers, & Wallmann, 2011). This result is similar to that of Suzuki et al. (2004) who reported improved psychological ratings (Profile of Mood State questionnaire) for rugby players who performed CWI compared to players who performed PAR after a rugby match.

From the above-mentioned research findings, it is clear that the execution of PAR and CWI immediately after high-intensity exercise may have the potential to bring about physiological and psychological recovery for athletes. Results would also suggest that compared to PAR, CWI is more beneficial for the psychological and physiological recovery of athletes. However, more research is needed to verify, especially the psychological benefits of CWI to participants of a contact sport such as rugby. Therefore the aim of this study was to determine the 48 hour post-exercise differences between the effects of PAR and CWI on the subscales of the RESTQ-Sport in university-level rugby players. Findings from this study may provide coaches and sport practitioners with clarity concerning the most effective recovery technique for the psychological and physiological recovery of rugby players.

Method

Participants

A group of twenty-three u/21 university-level rugby players (age: 20.1 ± 0.4 years) of a South African university's Rugby Institute voluntarily participated in this study. Only rugby players actively involved and training as members of the Rugby Institute as well as those who were totally injury free at the time of testing were eligible to participate in the study. The competitive

rugby-playing experience of these players varied between 4 and 15 years with an average of 10.2 ± 2.8 years. Players were firstly randomly divided into 12 backline and 11 forward players. Researchers did this to ensure that each group contained the same number of forward and backline players as differences in body composition may influence the response to especially CWI. The group was then again randomly divided into a control group (11 players) and an experimental group (12 players) by making use of the random sampling function of the Statistical Data Processing package (Statsoft Inc., 2014). The experimental group was subjected to CWI whereas the control group was subjected to PAR. All players were otherwise subjected to exactly the same testing procedures. The study design, purpose and possible risks of the study were explained to participants and written consent was obtained from participants before the investigation. Approval for the research was granted by the Ethics Committee of the institution where the research was conducted (Ethical number: NWU-00201-14-A1).

Each participant was instructed to sleep at least 8 hours during the evening and morning prior to the testing session. They also had to abstain from ingesting any drugs or participating in strenuous physical activities that may influence the physical or physiological responses of the body for at least 48 hours before the scheduled tests. Researchers ensured that participants did not participate in strenuous activities 48 hours before the scheduled tests by requesting coaches and sport scientists of relevant teams to provide information with regard to prior training sessions to the research team. Participants had to maintain the same normal diet during the week of testing. Participants also had to arrive at the testing sessions in a rested and fully hydrated state. Players were tested during the in-season phase of their periodization cycle. During the in-season phase the players spent an average of 1.8 ± 0.70 hours a day on weight training for 3.50 ± 0.90 days per week. They also spent an average of 2.4 ± 1.20 hours a day on field training sessions for 3.9 ± 0.70 days per week. During the time of testing they had already completed three months of a combined rugby conditioning program which consisted of field training sessions five times a week and gym resistance training sessions four times a week. Field training sessions were focused on rugby-specific drills, skills and activities aimed at improving the players' fitness levels. Gym resistance training sessions focused on improving players' functional muscle strength and explosive power.

Procedure

Research was conducted over three consecutive days for one week. During the first official day of testing players reported to the laboratory early in the morning for baseline values to be taken. Baseline testing took place in a fasting state just after players had woken up. Players completed the demographic and general information questionnaire as well as the RESTQ-Sport (pre-fitness). Baseline testing also consisted of the measurement of body mass and stature. After baseline measurements were taken, players were allowed to eat breakfast, after which they again reported to the laboratory in groups of four players each. Players were then subjected to a high-intensity fitness training session of 15 minutes (intervention). Exactly three minutes after the fitness session a 20 min CWI recovery session for the experimental group and 20 minutes of PAR for the control group were completed. The RESTQ-Sport was filled in again on the morning of the third day (post-recovery), 48 hours after the first completion of the RESTQ-Sport. The different morning measurements were repeated at exactly the same time of day so as to minimise the effects of circadian variations on the different physiological and psychological responses.

Measuring instruments***Demographic and general information questionnaire***

The demographic and personal information of players were collected by means of the above-mentioned questionnaire. The following information was also obtained by means of the questionnaire: players' ages, training habits, injury incidents, competing levels and best performances.

Anthropometric measurements

The following anthropometric components were determined according to the protocols of the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart, Marfell-Jones, Olds, & De Ridder, 2011) to describe the specific cohort of rugby players. Body mass was recorded to the nearest 0.1 kg, using a calibrated BFW 300 Platform scale (Adam equipment Co. Ltd., U.K.) and body stature to the nearest 0.1 cm, using a Harpenden portable stadiometer (Holtain Ltd., U.K.). Measurements were performed twice by a Level 2 ISAK certified Anthropometrist at the start of each testing session.

Recovery stress states

The RESTQ-Sport of Kellmann and Kallus (2001) is an instrument that systematically reveals the recovery stress states of athletes. The RESTQ-Sport consists of the following scales:

Table 3.1: The subscales of the RESTQ-Sport

General stress subscales:	General recovery subscales:
General stress	Success
Emotional stress	Social recovery
Social stress	Physical recovery
Conflicts/Pressure	General well-being
Fatigue	Sleep quality
Lack of energy	
Physical complaints	
Sport-specific stress subscales	Sport-specific recovery activity subscales
Disturbed breaks	Being in shape
Emotional exhaustion	Personal accomplishment
Injury	Self-regulation
	Self-efficacy

The RESTQ-Sport assesses potentially stressful and restful events and their subjective consequences during the past three days/nights. According to Kellmann and Kallus (2001), Cronbach alphas of above 0.7 were found for most of the scales within a month of testing, showing good internal consistency as well as test-retest reliability. A more recent study of Nederhof, Brink, and Lemmink (2008) also showed that the RESTQ-Sport had sufficient reliability and validity (> 0.6) for the use in sports practice and research. In a study of forty-one male university rugby players (mean age: 21.87 ± 1.39 years) acceptable Cronbach alphas of between 0.58 and 0.88 were calculated for 15 of the 19 subscales (Grobbelaar, Malan, Steyn, & Ellis, 2010).

Fitness session (Intervention)

A 10Hz GPS (Minimax V2.4, Catapult Sports, Victoria, Australia), was fitted to each player to record distance covered during execution of the session. Players completed a 15-minute, high-intensity fitness session on the rugby field while wearing rugby boots under the supervision of a

qualified Sport Scientist with more than 10 years of experience in the Sport Science field. The fitness session consisted of two rugby-simulating drills that targeted both the aerobic and anaerobic energy systems as well as activities required in rugby (tackling, sprinting, accelerating and decelerating). Players firstly sprinted a specific distance (forwards: 30 m and backs: 32.5 m) while changing direction once within 15s for 10 times, interspersed by 15s of active rest (jogging). Secondly, players completed a 5 m sprint followed by a tackle, a sprint back and then a 20 m sprint to a marker and back within a 30s time limit. Players rested passively for 30s between six sets. Forwards and backs covered 1820 ± 11 m and 1923 ± 4 m respectively during the fitness session.

Blood lactate measurement

Capillary blood samples were taken exactly 3 minutes after completion of the fitness session and used to analyse blood lactate by means of a Simplified Blood Lactate Test Meter (Lactate Pro LT-1710, Arkray Factory Inc., KDK Corporation, Shiga, Japan). The Lactate Pro Lactate Test Meter is a valid ($r = 0.975-0.993$) and reliable instrument for measuring blood lactate (Medbø, Mamen, Olsen, & Evertsen, 2000). The lactate test meter was calibrated according to the manufacturer's specifications at the beginning of the test day. A numeric result was displayed *via* an easy to read, large LCD screen within 60s after the blood sample had been drawn. Blood lactate was measured to ensure that the fitness session taxed the anaerobic glycolytic energy system totally and caused exhaustion.

Recovery sessions

Cold water immersion

Players submerged themselves in a cryotherapy bath up to their umbilicus for a period of 20 min while standing still. The cryotherapy bath was regulated at a temperature of $8 \pm 1^\circ\text{C}$. Participants had to keep their hands and arms folded over their chests and away from the water at all times. The reason why researchers decided to use 20 minutes as the period for CWI, was that the majority of CWI-related studies used CWI for at least 20 minutes (Rupp & Saliba, 2014).

Passive recovery

The control group was subjected to PAR during which they had to stay seated, fully clothed, for the whole 20 minute period in a laboratory, of which the temperature was regulated at 24°C .

Statistical analysis

The Statistical Data Processing Package (SPSS) for Windows (Version 22.0.0) was used to process data. Firstly, descriptive statistics (standard deviations, mean, minimum and maximum values) were reported for all variables measured during testing opportunities. Secondly, a Wilcoxon Signed Rank Test was performed to determine the significant differences in the RESTQ-Sport general stress, general recovery, sport-specific stress and the sport-specific recovery subscales between pre-fitness and post-recovery results within each of the groups (CWI and PAR). This was followed by the calculation of non-parametric effect sizes to determine the practical significance of changes in groups. Effect sizes were calculated by dividing z-scores that SPSS produced by the number of total observations (Field, 2007). Effect sizes of around 0.1, 0.3 and 0.5 were interpreted as small, medium and large, respectively (Field, 2007). Next, Levene's test was performed for each of the variables to assess the equality of variances between groups (Gastwirth, Gel, & Miao, 2009). In cases where Levene's test revealed a non-significant F-value the analysis of covariance (ANCOVA) (with adjustment for baseline values) was performed to identify significant differences in RESTQ-Sport subscale scores between the CWI and PAR groups. However, in cases where Levene's test revealed a significant F-value, the non-parametric Quade's ranks ANCOVA was applied. The level of significance was set at $p \leq .05$.

Results

Changes in RESTQ-Sport subscales from pre-fitness to post-recovery time periods

Table 3.2 presents the descriptive statistics as well as results with regard to significant differences in general stress and recovery subscales between the pre-fitness and post-recovery time periods of the control group. Tabulated results show that conflicts/pressure and success were the only RESTQ-Sport subscales that displayed statistically ($p < .05$) and practically significant ($d \sim 0.5$) decreases from the pre-fitness to post-recovery time periods. Only social recovery showed a large practically significant ($d \sim 0.5$) decrease from the pre-fitness to post-recovery time periods. General stress and physical recovery showed medium practically significant ($d \sim 0.4$) increases over the 48 hour recovery period. General well-being exhibited a medium practically significant ($d \sim 0.4$) decrease over the 48 hour recovery period. Values of all other subscales remained more or less the same over 48 hours.

Table 3.2: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport general stress and recovery-subscale between the pre-fitness and post-recovery time periods of the control group (PAR)

RESTQ subscales	N	Pre-anaerobic		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
General stress subscale	11	1.57	0.50	1.59	0.60	0.88	0.05[#]
General stress	11	1.45	0.93	1.77	1.17	0.16	0.42 ^{##}
Emotional stress	11	1.27	0.85	1.59	1.00	0.48	0.21 [#]
Social stress	11	1.50	0.92	1.50	0.89	0.72	0.11 [#]
Conflicts/Pressure	11	2.68	0.75	2.00	1.07	0.01 [*]	0.74 ^{###}
Fatigue	11	1.86	0.92	1.86	0.92	0.93	0.03 [#]
Lack of energy	11	1.59	0.83	1.73	0.82	0.67	0.13 [#]
Physical complaints	11	0.64	0.50	0.68	0.51	0.77	0.09 [#]
General recovery subscale	11	3.21	0.67	3.19	0.77	0.82	0.07[#]
Success	11	3.27	0.82	2.82	1.01	0.04 [*]	0.62 ^{###}
Social recovery	11	3.68	1.59	3.45	1.39	0.09	0.52 ^{###}
Physical recovery	11	2.59	0.94	3.09	1.28	0.16	0.42 ^{##}
General well-being	11	3.50	0.77	3.27	0.56	0.32	0.30 ^{##}
Sleep quality	11	3.00	1.38	3.32	1.38	0.61	0.16 [#]

* Statistically significant ($p \leq .05$); # Small effect size ~ 0.1 , ## Medium effect size ~ 0.3 , ### Large effect size ~ 0.5

Table 3.3 presents the descriptive statistics as well as results with regard to significant differences in sport-specific stress and recovery subscales between the pre-fitness and post-recovery time periods of the control group.

Table 3.3: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport sport-specific stress and sport-specific recovery activity subscales between the pre-fitness and post-recovery time periods of the control group (PAR)

RESTQ subscales	N	Pre-anaerobic		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
Sport-specific stress subscale	11	1.62	0.80	1.49	0.77	0.06	0.58^{###}
Disturbed breaks	11	1.41	0.97	1.40	0.84	0.51	0.21 [#]
Emotional exhaustion	11	1.55	1.01	1.40	0.97	0.44	0.25 [#]
Injury	11	1.91	1.36	1.68	0.93	0.10	0.52 ^{###}
Sport-specific recovery activity subscale	11	3.35	0.84	2.87	0.71	0.11	0.50^{###}
Being in shape	11	3.39	1.06	2.70	0.93	0.04 [*]	0.64 ^{###}
Personal accomplishment	11	2.98	1.04	2.80	0.70	0.68	0.13 [#]
Self-efficacy	11	3.68	1.03	3.20	1.00	0.24	0.37 ^{##}
Self-regulation	11	3.45	1.24	2.78	1.14	0.02 [*]	0.71 ^{###}

* Statistically significant ($p \leq .05$); # Small effect size ~ 0.1 , ## Medium effect size ~ 0.3 , ### Large effect size ~ 0.5

Results of Table 3.3 show that being in shape and self-regulation were the only subscales that indicated statistical ($p < .05$) and practically significant ($d \sim 0.5$) decreases from pre-fitness to post-recovery time periods. Although not statistically significant, the injury sport-specific stress and recovery subscales displayed large practically significant ($d \sim 0.5$) reductions in values over the 48 hour recovery period. Self-efficacy revealed medium practically significant ($d \sim 0.3$) reductions in values over the 48 hour recovery period. All other subscale values remained more or less the same over the last-mentioned time period.

Table 3.4 presents the descriptive statistics as well as results with regard to significant differences in general stress and recovery subscales between the pre-fitness and post-recovery time periods of the experimental group.

Table 3.4: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport general stress and general recovery subscales between the pre-fitness and post-recovery time periods of the experimental group (CWI)

RESTQ subscales	N	Pre-fitness		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
General stress subscale	12	1.65	0.65	1.41	0.54	0.07	0.37^{##}
General stress	12	1.25	0.94	0.92	0.70	0.11	0.35 ^{##}
Emotional stress	12	1.71	0.78	1.46	0.50	0.30	0.21 [#]
Social stress	12	1.71	0.78	1.25	0.50	0.09	0.35 ^{###}
Conflicts/Pressure	12	2.08	1.14	1.83	0.86	0.23	0.25 [#]
Fatigue	12	1.67	0.89	1.58	0.93	0.78	0.06 [#]
Lack of energy	12	2.04	0.66	1.92	0.85	0.62	0.10 [#]
Physical complaints	12	1.13	0.83	0.92	0.70	0.32	0.20 [#]
General recovery subscale	12	3.94	0.45	3.47	0.64	0.01[*]	0.55^{###}
Success	12	3.63	0.93	2.83	0.72	0.01 [*]	0.52 ^{###}
Social recovery	12	4.92	0.70	4.29	1.10	0.02 [*]	0.46 ^{###}
Physical recovery	12	3.50	0.64	2.92	1.00	0.01 [*]	0.51 ^{###}
General well-being	12	4.17	0.83	3.88	0.53	0.25	0.23 [#]
Sleep quality	12	3.50	0.90	3.42	0.76	0.52	0.13 [#]

* Statistically significant ($p \leq .05$); # Small effect size ~ 0.1 , ## Medium effect size ~ 0.3 , ### Large effect size ~ 0.5

For the experimental group, success, general, social and physical recovery were the only RESTQ-Sport subscales that displayed statistically ($p < .05$) and practically significant ($d \sim 0.5$) decreases from pre-fitness to post-recovery time periods. The general (major and minor) and social stress subscales showed medium practically significant ($d \sim 0.3$) reductions in values over the 48 hour recovery period. All other subscale values remained more or less the same over the last-mentioned time period.

Table 3.5 presents the descriptive statistics as well as results with regard to significant differences in sport-specific stress and recovery subscales between the pre-fitness and post-recovery time periods of the experimental group.

Table 3.5: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport sport-specific stress and sport-specific recovery activity-subscales between the pre-fitness and post-recovery time periods of the experimental group (CWI)

RESTQ subscales	N	Pre-fitness		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
Sport-specific stress subscale	12	1.57	0.72	1.18	0.54	0.01[*]	0.57^{###}
Disturbed breaks	12	1.31	0.80	0.93	0.63	0.09	0.35 ^{##}
Emotional exhaustion	12	1.25	0.99	1.04	0.78	0.15	0.29 [#]
Injury	12	2.15	0.88	1.56	0.68	0.01 [*]	0.54 ^{###}
Sport-specific recovery activity subscale	12	3.73	0.79	3.21	0.93	0.00[*]	0.63^{###}
Being in shape	12	3.83	1.05	3.31	0.95	0.01 [*]	0.55 ^{###}
Personal accomplishment	12	3.38	1.05	2.96	1.12	0.07	0.37 ^{##}
Self-efficacy	12	3.98	0.79	3.31	1.03	0.00 [*]	0.60 ^{###}
Self-regulation	12	3.73	0.99	3.27	1.21	0.04 [*]	0.43 ^{##}

* Statistically significant ($p \leq .05$); Effect sizes of 0.1 = small (#), 0.3 = medium (##), 0.5 = large (###)

Injury, being in shape, self-efficacy, sport-specific stress, sport-specific recovery and self-regulation all revealed statistically ($p < .05$) and large practically significant ($d \sim 0.5$) decreases from pre-fitness to post-recovery time periods. Although not statistically significant so, disturbed breaks and personal accomplishment showed medium practically significant ($d \sim 0.3$) reductions in values over the 48 hour recovery period. Emotional exhaustion was the only subscale score that remained more or less the same over the last-mentioned time period.

Comparison of RESTQ-Sport subscale changes between the CWI and PAR groups

Table 3.6 presents results of the normal analysis and Quade's ranks ANCOVA for the RESTQ-Sport subscale changes between the PAR and CWI groups.

Table 3.6: Results of the normal analysis and Quade's ranks ANCOVA for the RESTQ-Sport subscale changes between the PAR and CWI groups

RESTQ Subscales	F-value	P-value
General stress subscale	0.24	0.63
General stress	0.01	0.92
Emotional stress	0.02	0.88
Social stress	0.30	0.59
Conflicts/Pressure	3.00	0.10
Fatigue	0.01	0.91
Lack of energy	0.50	0.49
Physical complaints	0.21	0.65
General recovery subscale	0.18	0.67
Success	2.47	0.13
Social recovery	1.12	0.30
Physical recovery	1.87	0.19
General well-being	0.13	0.72
Sleep quality	0.15	0.70
Sport-specific stress subscale	0.99	0.33
Disturbed breaks	0.15	0.71
Emotional exhaustion	0.06	0.81
Injury	0.24	0.63
Sport-specific recovery activity subscale	6.59	0.02*
Being in shape	0.16	0.70
Personal accomplishments	2.86	0.11
Self-efficacy	7.95	0.01*
Self-regulation	0.92	0.35

*Statistical significance ($p \leq .05$)

Significant F-values were observed for the following subscales: Emotional stress ($p = .014$), social recovery ($p = .006$), self-efficacy ($p = .022$) and the sport-specific recovery subscale ($p = .016$), which meant that the comparative analysis was not performed by means of a normal ANCOVA but rather with the Quade's ranks ANCOVA. The rest of the variables were, however, analysed by means of a normal ANCOVA. From Table 3.6 it is clear that only the sport-specific recovery and self-efficacy subscales showed a significant difference ($p < .05$) between the PAR and CWI groups. For both of these subscales the CWI group experienced a significantly larger decrease than the PAR group.

Discussion

To the researchers' knowledge this is the first study to investigate and compare the effects of CWI and PAR on the subscales of the RESTQ-Sport after an exercise intervention in rugby players. Surprisingly, even though the CWI group displayed statistically and practically significant pre-fitness to post-recovery changes for a larger number of the RESTQ-Sport subscales compared to the PAR group, only sport-specific recovery and self-efficacy showed a more pronounced significant decrease in the CWI-group compared to the PAR-group. However, the reader must take note that in cases where PAR or CWI had the desired recovery effect on the RESTQ-Sport subscales of players, post-recovery values would be more or less similar to those of pre-fitness values and would therefore *not* obtain statistically or practically significant differences. This would mean that players' subscale values returned to levels that were observed before the execution of the exhausting fitness session. On the other hand, it is also possible that the different recovery techniques had a positive effect on players' negative subscales (such as general stress, emotional stress, social stress, conflicts/pressure, fatigue, lack of energy, physical complaints, disturbed breaks, emotional exhaustion and injury), with values that significantly decreased from the pre-fitness to the post-recovery time period. *Vice versa*, recovery techniques may also lead to a significant increase in positive subscales such as success, social recovery, physical recovery, general well-being, sleep quality, being in shape, personal accomplishment, self-efficacy and self-regulation from the one time period to the next.

In view of the last-mentioned explanation, it is clear that PAR resulted in the recovery of the majority of general stress (6 out of 7) and the minority of the general recovery subscales (2 out of 5). Success, social recovery and general well-being were all subscales of which scores were negatively affected ($d \geq 0.3$) by PAR over the 48 hour period. Nevertheless, the general stress

and recovery subscale scores remained the same from pre-fitness to post-recovery which indicates that the desired recovery effect was achieved. All the sport-specific stress-related subscales were positively influenced by PAR (3 out of 3) whereas most of the sport-specific recovery activity-related subscales (3 out of 4) were negatively influenced by the 48-hour recovery period. Being in shape, self-efficacy and self-regulation all showed practically significant ($d > 0.3$) downward trends from the pre-fitness to the post-recovery period. This gave rise to practically significant decreases in both the sport-specific stress and recovery subscales. Therefore, although PAR positively influenced the sport-specific stress subscale score, it had a negative influence on the sport-specific recovery subscale score.

The positive results of the physical recovery, physical complaints and emotional stress subscales due to PAR are in line with findings of Brophy-Williams et al. (2011) that showed significant ($p = .00$) increases in the perceived recovery score after high intensity treadmill running. However, the majority of studies that have thus far investigated the effects of PAR on recovery of sports participants are in contrast with results of this study with regard to improvements in the lack of energy, fatigue, physical recovery and physical complaints subscales. For example, researchers found that neither perceived muscle soreness nor perceived fatigue improved post-exercise in well-trained runners (Hausswirth et al., 2011) or in soccer players (Rey et al., 2012) due to PAR. Moreover, another study reported that cyclists' legs felt heavy and stiff between cycling trials when PAR was used as a recovery technique (Lane & Wenger, 2004).

One possible reason for differences in the outcomes of PAR between this and other studies is methodological differences. For example, Hausswirth et al. (2011) administered PAR for 30 minutes at a room temperature of 24°C compared to our study that administered PAR for 20 minutes at 24°C. Furthermore, last-mentioned researchers subjected their participants to a simulated trial run of 48 minutes whereas our study made use of a 15-minute fitness intervention. Participants in the study of Lane and Wenger (2004) performed intermittent cycling sessions that consisted of a 15 minute warm-up and 22 repetitions of cycling bouts of varying durations for 18 minutes. Tessitore et al. (2007) subjected participants to a program of 100 min that consisted of a warm-up of 15 min, individual, group and team technical drills of 65 minutes and circuit training of 20 minutes. Differences in the type of interventions used will definitely influence participants' responses to PAR. In this regard, different physiological mechanisms are affected by different types and intensities of exercises (Wilcock, Cronin, & Hing, 2006). For example,

higher intensity exercises that demand more eccentric muscle contractions will give rise to muscle damage and oedema which may increase both transport route and compression of localised capillaries, reducing oxygen delivery to localised cells (Wilcock et al., 2006). All of these factors will negatively influence the recovery process and the mechanisms that are involved during recovery.

Another possible reason for differences in results between studies is the use of different psychometric instruments and measurements times. For example, Rowsell, Coutts, Reaburn, and Hill-Haas (2009) measured general fatigue and leg soreness 22h after completion of a soccer game, by using a 10-point Likert Scale. Other researchers measured perceived fatigue in basketball players pre- and immediately post-game across 3 days, by using the Visual Analogue Scale (Montgomery et al., 2008). Brophy-Williams et al. (2011) used the Total Quality Recovery Perception scale to measure the perception of recovery 24h after a high-intensity interval session whereas our study made use of the RESTQ-Sport questionnaire for athletes, which was filled in 48h post-recovery. Differences in psychometric instruments as well as timing of measurements complicate comparisons of results between studies.

Results from the present study indicated that PAR had a negative effect on the general well-being, being in shape, self-efficacy and self-regulation subscales. In contrast, De Nardi et al. (2011) found a non-significant decrease in levels of perceived fatigue in soccer players after specific soccer drills in the PAR group. In another study, PAR had no effect on muscle soreness or perceived fatigue in Australian football players (Elias et al., 2012). Participants' prior belief regarding the effectiveness or ineffectiveness of a specific recovery technique, preconceptions about a recovery technique or preference may influence the psychological benefits that are derived from the technique (Stacey et al., 2010; Wager, 2005). It is therefore possible that prior beliefs or perceptions about the effectiveness of PAR as a recovery technique played a role in the more positive response that participants showed with regard to fatigue, lack of energy, physical complaints, physical recovery, emotional exhaustion and personal accomplishment subscales, compared to participants of other studies. In addition, researchers suggest that athletes perform better when they believe that they receive beneficial treatment (Beedie, 2007).

Furthermore, even though blood lactate measurements indicated that exhaustion occurred due to the fitness session (average value of 5.2 ± 2.7 mmol/L), the rather short duration of the session

(15 min) possibly led to less muscle damage than would have been the case with a longer session duration. A lower degree of muscle damage may have led to the perception among participants that PAR was more effective as a recovery technique compared to situations where a lot of muscle damage occurs. This notion was supported by Stacey et al. (2010) who showed that participants', who felt less pain and muscle soreness which is probably caused by muscle damage, had a heightened sense of well-being after recovery. Therefore, the nature of the fatiguing exercise or exercise session, the intensity of the exercise session and type of muscle contractions performed during the session as well as the physiological and psychological responses due to the session may play a role in the recovery benefits of PAR (Juliff et al., 2014; Lattier et al., 2004; Stacey et al., 2010).

In contrast to PAR, CWI resulted in the recovery of all the general stress subscales (7 out of 7). Despite this, CWI led to the recovery of a minority of general recovery subscales (2 out of 5). Success, social and physical recovery were all subscales of which scores were negatively affected ($d > 0.4$) by CWI over the 48 hour period. Another difference from PAR was that scores for the general stress and recovery subscales decreased significantly ($d = 0.37$; $d = 0.55$) from pre-fitness to post-CWI. Similar to responses of PAR, all sport-specific stress-related subscales were positively influenced by PAR (3 out of 3) whereas all the sport-specific recovery activity-related subscales (4 out of 4) were negatively influenced by CWI during the 48-hour recovery period. Being in shape, personal accomplishment, self-efficacy and self-regulation showed a practically significant downward trend from the pre-fitness to the post-recovery period. The last-mentioned results contributed to practically significant decreases in both the sport-specific stress and sport-specific recovery activity subscales. So even though CWI caused the sport-specific stress score to decrease, it also led to a lower sport-specific recovery subscale score.

CWI positively influenced emotional stress, fatigue, lack of energy, physical complaints, disturbed breaks and emotional exhaustion in the present study. Similar studies found that CWI led to significant decreases ($p < .05$) in the perception of muscle soreness and fatigue after a match and an exercise session in soccer players (Ascensão et al., 2011; De Nardi et al., 2011). Moreover, Brophy-Williams et al. (2011) found that CWI post-exercise significantly increased the perception of recovery (as defined by the TQRP scores) immediately ($p = .02$) and 3 hours ($p = .04$) after high-intensity treadmill running. Broatch, Petersen, and Bishop (2014) also reported significant increases ($p < .05$) in the ratings of physical and mental readiness for

exercise when CWI was performed after high-intensity exercise on a cycle ergometer. Others found that CWI post-exercise resulted in significantly higher scores ($p < .05$) in perceived recovery and lower scores in perceived leg soreness in junior male soccer and rugby players (Pointon & Duffield, 2012; Rowsell et al., 2009).

Several possible reasons may be provided for the beneficial effects of CWI on especially the general stress and sport-specific stress-related subscales of rugby players. Players may experience a weightless sensation when being immersed in water (Wilcock et al., 2006), which together with an analgesic effect may give rise to a feel-good perception (Stacey et al., 2010). Analgesia can also help to reduce the perception of muscle soreness (Elias, 2013). According to Broatch et al. (2014), athletes' prior beliefs in the benefits of CWI may also serve as a contributing factor to the decreased perceptions of fatigue (decreases in general stress-related scores).

CWI negatively affected the general recovery (success, social and physical recovery) and sport-specific recovery activity subscales (physical recovery, being in shape and personal accomplishment) in the present study, which was similar to what other studies found. For example, CWI led to a non-significant increase ($p > .05$) in the quality of recovery and the perception of less stiff and heavy legs after a 90-minute soccer match (Kinugasa & Kilding, 2009). Vaile, Halson, Gill and Dawson (2008a) also reported that CWI (14 min at 15°C) was ineffective in decreasing pain perception after eccentric exercises (7 x 10 eccentric exercises on a leg press machine). Similarly, CWI (10 min at 15°C) did not reduce the perception of effort (Vaile et al. 2008b) or restored muscle damage after an 80-minute simulated rugby game (Takeda et al., 2014).

Several possible reasons for differences in the outcome of CWI between our study and other studies could be provided. As has been mentioned before, methodological differences with regard to application times and temperatures of CWI between studies could cause different responses. In this regard, Bahnert et al. (2013) administered 8 min of CWI at 6-11°C, Ascensão et al. (2011) 10 min of CWI at 10°C, Broatch et al. (2014) 15 min of CWI at 14°C and Brophy-Williams et al. (2011) CWI of 15 min at 15°C, whereas our study administered CWI for 20 minutes at 8°C. Low water temperatures of CWI will lead to skin temperature changes which will improve the comfort level of participants due to the body temperature that returns to

physiological normality, because skin temperature is an essential component of a human's perception and comfort (Flouris, 2011). The hydrostatic pressure and low temperatures experienced during CWI may lead to an increase in the translocation of substrates from the muscles, reducing peripheral resistance and increasing the body's ability to transport substrates (Wilcock et al., 2006). Therefore, reduced oedema may improve nutrient delivery and facilitate recovery from exercise that has induced muscle damage (Wilcock et al., 2006). However, prolonged exposure to cold may have negative effects, from a recovery perspective, because blood flow increases in the muscles when the muscle temperature reaches about 10°C (Lambert & Van Wyk, 2009:6). Furthermore, very cold temperatures are better to treat acute injuries and reduce inflammation in a localised manner, rather than being used as a recovery strategy (Wilcock et al., 2006). Last-mentioned researchers also concluded that immersion in cool to thermoneutral water may provide the best option for recovery unless muscle sprains or strains have occurred, in which case cold water immersion may provide greater benefit (Wilcock et al., 2006). Hence, difference in water temperatures used and the duration of CWI may influence the types of mechanisms that are involved during the recovery process.

The discrepancy between some of the results may also be related to the extent of muscle damage that occurred due to eccentric muscle contractions during exercise (Vaile et al., 2008a), intermittent cycling sessions (Lane & Wenger, 2004), competitive game and/or matches (Ascensão et al., 2011; Bahnert et al., 2013; Delextrat et al., 2013) versus high-intensity exercise, as was the case in the present study. For team sport athletes, the ability to sprint and change direction are important and may negatively influence the result of competitive matches, if full recovery is not achieved (Elias, Wyckelsma, Varley, McKenna & Aughey, 2013). Oedema in response to exercise or muscle damage may increase both the transport route and compression of localised capillaries, reducing oxygen delivery to localised cells (Wilcock et al., 2006). Furthermore, exercise causes a shift of plasma from the blood into the muscles (Wilcock et al., 2006).

In view of the above-mentioned results and previous findings researchers expected CWI to lead to significantly better ($p \leq .05$) changes in the RESTQ-Sport subscales among university-level rugby players than PAR. However, the only subscales that revealed a more pronounced significant decrease from pre-fitness to post-recovery changes in the CWI- compared to the PAR-group, were sport-specific recovery and self-efficacy (Table 3.6). Studies that have

compared CWI to PAR in a sport context reported CWI to be significantly more beneficial, especially in reducing post-exercise perceived muscle soreness (Duffield et al., 2014; Ingram et al., 2009; Pointon & Duffield, 2012), and perceptions of fatigue (Brophy-Williams et al., 2011; De Nardi et al., 2011; Elias et al., 2012). Furthermore, Ingram et al. (2009) concluded that CWI after an exhaustive simulated team sports exercise offered significantly greater recovery benefits (lower muscle soreness ratings, $p < .05$) 48-h post-exercise than PAR. Researchers also suggest that CWI is an effective recovery technique for contact-based sports (Pointon & Duffield, 2012).

Various factors may provide reasons for the fact that not all RESTQ-Sport subscale values revealed better pre-fitness to post-recovery changes for CWI compared to PAR. For instance, the use of a very low temperature during the execution of CWI (8°C) may have caused pain and discomfort to participants which would negatively impact the possible recovery benefits of CWI (Elias, 2013). The negative influence would be a particular concern to players who are sensitive to cold. Furthermore, cutaneous interstitial pressure increases proportionally with the depth of immersed body parts (Montgomery et al., 2008). The proportional change in pressure with depth causes an upward squeezing action on the body which may increase the movement of fluids and the consequent removal of waste products from the body (Wilcock et al., 2006). Therefore, the use of a shallower immersion depth during the execution of CWI in this study (up to the level of the umbilicus) would probably be less effective in causing recovery than making use of a deeper immersion depth (up to neck-level).

Despite the fact that not all RESTQ-Sport subscale values were more positively influenced by CWI compared to PAR, CWI led to a more pronounced significant decrease in sport-specific recovery and self-efficacy subscales. According to Algafly and George (2007) the decrease in skin and muscle temperature during CWI, may cause a reduction in nerve conduction velocity rate which would interrupt the cycle of pain and reduce muscle spasms. In addition, after 15 minutes of CWI the smooth muscles in the vascular wall of blood vessels that are beneath the skin, become paralysed because of the drop in skin temperature and this causes sudden vasodilatation which leads to an abrupt rush of blood to the skin (Guyton & Hall, 2015). Blood flow to muscles will now increase with a resultant increase in the removal, buffering and break down of waste products such as muscle lactate (Guyton & Hall, 2015). All of these factors may explain the more positive influence of CWI on sport-specific recovery and self-efficacy compared to PAR.

Conclusion

Due to the fact that sport-specific recovery and self-efficacy were the only RESTQ-Sport subscales that revealed a more pronounced significant decrease for pre-fitness to post-recovery changes in the CWI-group compared to the PAR-group, researchers concluded that CWI was more beneficial in causing 48 hours post-exercise recovery in the minority of subscales compared to PAR. These results are contrary to previous findings which in general showed that CWI led to much better recovery responses than PAR. However, the unique nature of this study demonstrated that CWI and PAR positively influenced the stress subscale scores and can assist in the psychological recovery of athletes' post-exercise. Nevertheless, further research is needed to verify the effectiveness of CWI and PAR on recovery of RESTQ-Sport subscales after high-intensity exercise.

In view of the above-mentioned research findings, researchers suggest that future research should make use of longer durations of exercise interventions when investigating the possible influence of especially CWI on the RESTQ-Sport subscales of athletes. A rugby game or full training session would probably serve as a better and more sport-specific intervention to cause physiological and psychological fatigue than a fitness-session that makes use of rugby-specific drills and activities. It can also be recommended that players, coaches and practitioners should rather use a combination of recovery techniques in order to ensure effective recovery of athletes. It is also advisable to evaluate and consider individual players' unique physiological and psychological responses to recovery techniques when choosing the most effective technique for acute recovery between training sessions and matches. In view of the last-mentioned statement athletes should also be educated about psychological skills such as attention control, goal setting, imagery, relaxation and self-talk, which can be used to improve the recovery and decrease stress levels during training and competition (Kuan & Kueh, 2015).

The following also need to be considered when interpreting results: The use of subjective methods to monitor the possible effect of recovery techniques has some limitations, as it requires honest responses and a thorough understanding of the RESTQ-Sport instrument by athletes (Freitas, Nakamura, Miloski, Samulski, & Bara-Filho, 2014). Individual differences in effort capacity, external stressors not related to training and stress tolerance levels may also influence participants' responses to the RESTQ-Sport (Noce et al., 2008). Furthermore, the need for a homogeneous group of players, limited the sample size of this study, which affected the

statistical significance of results. In addition, it probably would be of more value to monitor individual responses of each player to a specific recovery intervention, over time in order to pick up subtle changes in RESTQ-Sport subscales which may have a positive impact on a player's performance (Tessitore et al., 2007). Despite all these limitations findings from this study provide sport scientists, sport psychologists, coaches and rugby players with some clarity regarding the efficacy of CWI and PAR as recovery interventions.

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CHAPTER 4

4. Differences between the 48-hour post-exercise effects of passive recovery and contrast water therapy on the subscales of the Recovery-Stress Questionnaire in rugby players

This article will be submitted for publication in the *Journal of Applied Sport Psychology*. This article is hereby included according to the specific prescriptions of the journal. Although not in accordance with the guidelines of the journal, tables were included in the text to make the article easier to read and understand. Furthermore, the line spacing of the article was set at one and a half lines and the first line of each paragraph not indented as to conform to the rest of the layout of the dissertation. The instructions for authors are included as Appendix F: Guidelines for authors: Journal of Applied Sport Psychology.

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DIFFERENCES BETWEEN THE 48-HOUR POST-EXERCISE EFFECTS OF PASSIVE RECOVERY AND CONTRAST WATER THERAPY ON THE SUBSCALES OF THE RECOVERY-STRESS QUESTIONNAIRE IN RUGBY PLAYERS

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Abstract

This study determined the differences in the 48-hour post-recovery effects of passive recovery (PAR) and contrast water therapy (CWT) on the subscales of the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) in university level-rugby players after a high-intensity fitness session of 15 minutes. The RESTQ-Sport was completed by twenty-three under 21 rugby players who either completed PAR or CWT for 20 minutes. Results showed that PAR and CWT affected the subscales scores differently in rugby players. Inter-group changes revealed that self-efficacy as well as sport-specific stress and recovery were significantly ($p < .05$) more positively affected by CWT compared to PAR whereas PAR was more effective in causing positive changes in emotional stress and success compared to CWT over the 48-hour period.

Keywords: contrast water therapy; passive recovery; psychological recovery; rugby, Recovery-Stress Questionnaire

Introduction

Rugby is an intense team sport which places high physiological and psychological demands on players (Gill, Beaven, & Cook, 2006). High match demands have led to a widespread belief among coaches and players that large volumes of intense training must be performed to maximise gains in performance (Coutts, Reaburn, Piva, & Rowsell, 2007; Stacey, Gibala, Martin, Ginis, & Timmons, 2010). However, high training volumes tied with insufficient recovery periods have been associated with a decline in performance (Hamlin, 2007), the

development of fatigue and an increased risk of sustaining injuries (Hing, White, Bouaaphone, & Lee, 2008). Therefore, the emphasis in training must be on establishing the appropriate balance between recovery and training stimuli to maintain optimal performance and enhance both physiological and psychological recovery (Reilly & Ekblom, 2005; Suzuki et al., 2004). As a result of this phenomenon, players need to include recovery strategies in their training and competition regimes (De Nardi, La Torre, Barassi, Ricci, & Banfi, 2011; Venter, 2012). However, despite a growing interest in optimal recovery techniques, most studies only focus on the physiological benefits of these techniques (Lane & Wenger, 2004; Vaile, O'Hagan, Stefanovic, Walker, Gill, & Askew, 2011; Vaile, Halson, Gill, & Dawson, 2008), and often neglect the psychological benefits and effects of recovery techniques (Stacey et al., 2010).

The recovery techniques currently used by athletes include contrast water therapy (CWT) and passive recovery (PAR) (Barnett, 2006). PAR requires that athletes rest passively for a certain duration of time and allows the body to recover without any intervention (Lambert & Van Wyk, 2009). PAR therefore involves that participants sit still and do no more than their everyday routine during the rest period (Lattier, Millet, Martin, & Martin, 2004; Suzuki et al., 2004). A comparison between the influence of PAR (lying down for 5 min), AR (light pedalling on cycle ergometer for 5 min at 60 rpm) and stretching (isometric contractions for a duration of 5 min) on muscle relaxation after dynamic exercises showed that light, active exercises were more effective in causing muscle relaxation in ten healthy males than PAR (Mika, Mika, & Fernhall, 2007). Similarly, PAR for 48h post-exercise did not significantly reduce pain or perceived tiredness after exercise in well-trained runners (Hauswirth et al., 2011). However, Suzuki and co-workers (2004) reported that rugby players' mood states (as measured by the Profile of Mood States (POMS)) were positively influenced ($p < .05$) by the use of PAR post-exercise.

As mentioned, CWT is another post-exercise recovery technique that athletes use to facilitate the recovery process. CWT involves immersion of different body parts or the entire body in cold water (8-15°C for 30-60s) immediately followed by immersion in warm water (38-42°C for 1-3.5min) for a total duration of 6 to 15 minutes (Coffey, Leveritt, & Gill, 2004; Gill et al., 2006; Hamlin, 2007b; Sayers, Calder, & Sanders, 2011). Researchers suggest that CWT is a better recovery strategy for athletes due to a decrease in blood lactate concentrations and the perception of fatigue (Coffey et al., 2004; Kuligowski, Lephart, Giannantonio, & Blanc, 1998; Sayers et al., 2011), less tight muscles and a heightened feeling of mental freshness post-exercise

(Morton, 2007). However, despite the proven benefits and use of CWT by athletes, Barnett (2006) concluded that more scientific research is needed to support the use of CWT as a recovery technique.

Though research verifies especially the physiological benefits of using various recovery techniques post-exercise, researchers need to acknowledge that physiological recovery is only one aspect of the recovery process and that the psychological benefits of these techniques should also be investigated. Accelerated physiological recovery gives the athlete more time to address important psychological recovery strategies (Hogg, 2002). Furthermore, physiological and psychological responses to recovery techniques are connected (Stacey et al., 2010). However, coaches will need to monitor athletes in order to determine the recovery status and to bring athletes back to a balanced stress-recovery state (Nel, 2012). Any imbalances in the stress-recovery state that are not immediately taken care of can result in overtraining and burnout (Nel, 2012). Certain psychometric measuring instruments such as the Stellenbosch Mood Scale (STEMS) (Terry, Potgieter, & Fogarty, 2003), the POMS questionnaire (McNair, Lorr, & Droppelman, 1971), the Daily Analyses of Life Demands for Athletes questionnaire (DALDA) (Rushall, 1990), and the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) (Kellmann, 2010; Kenttä, Hassmén, & Raglin, 2006) are used by researchers for monitoring purposes.

Nonetheless, an advantage of the RESTQ-Sport is that it has a systematic multi-level approach that allows practitioners and sport scientists to provide recommendations that are specific to certain intervention strategies and use results to plan recovery strategies and techniques (Nel, 2012:40), which seems to be a more ideal instrument in this regard. The RESTQ-Sport does not only assess potentially stressful and restful events, but the subjective consequences of these events on both the physiological and psychological components of athletes (Kellmann & Kallus, 2001). Despite the value and benefits of the RESTQ-Sport no researchers have up until now investigated the psychological and physiological post-recovery responses of team sport participants by making use of this instrument. Therefore the aim of this study was to determine the 48-hour post-exercise differences between the effects of PAR and CWT on the subscales of the RESTQ-Sport in university-level rugby players. Findings from this study may provide coaches and sport practitioners with clarity concerning the most effective recovery technique for the recovery of rugby players.

Method

Participants

A group of twenty-three ($n=23$) u/21 university-level rugby players (age: 20.1 ± 0.4 years) of a South African university's Rugby Institute voluntarily participated in this study. Only rugby players actively involved and training as members of the Rugby Institute as well as those who were totally injury free at the time of testing were eligible to participate in the study. The competitive rugby-playing experience of these players varied between 4 and 15 years with an average of 10.2 ± 2.8 years. Players were firstly randomly divided into 12 backline and 11 forward players. Researchers did this to ensure that each group contained the same number of forward and backline players as differences in body composition may influence the response to especially CWT. The group was then again randomly divided into a control group (11 players) and an experimental group (12 players) by making use of the random sampling function of the Statistical Data Processing package (Statsoft Inc., 2014). The experimental group was subjected to CWT whereas the control group was subjected to PAR. All players were otherwise subjected to exactly the same testing procedures. The study design, purpose and possible risks of the study were explained to participants and written consent was obtained from participants before the investigation. Approval for the research was granted by the Ethics Committee of the institution where the research was conducted (Ethical number: NWU-00201-14-A1).

Each participant was instructed to sleep at least 8 hours during the evening and morning prior to testing sessions. They also had to abstain from ingesting any drugs or participating in strenuous physical activities that may influence the physical or physiological responses of the body for at least 48 hours before the scheduled tests. Researchers ensured that participants did not participate in strenuous activities 48 hours before scheduled tests by requesting the coach and sport scientist of the relevant teams to provide information with regard to prior training sessions to the research team. Participants had to maintain the same, habitual diet during the week of testing. Participants also had to arrive at testing sessions in a rested and fully hydrated state. Players were tested during the in-season phase of their periodization cycle. During the in-season phase the players spent an average of 1.8 ± 0.70 hours a day on weight training for 3.50 ± 0.90 days per week. They also spent an average of 2.4 ± 1.20 hours a day on field training sessions for 3.9 ± 0.70 days per week. During the time of testing they had already completed three months of a combined rugby conditioning program which consisted of field training sessions five times a week and gym resistance training sessions four times a week. The field training sessions were

focused on rugby-specific drills, skills and activities aimed at improving players' fitness levels. Gym resistance training sessions focused on improving players' functional muscle strength and explosive power.

Procedure

Research was conducted over three consecutive days for one week. During the first official day of testing players reported to the laboratory early in the morning for baseline values to be taken. Baseline testing took place in a fasting state just after players had woken up. Players completed the demographic and general information questionnaire as well as the RESTQ-Sport (pre-fitness). Baseline testing also consisted of the measurement of body mass and stature. After baseline measurements were taken, players were allowed to eat breakfast, after which they again reported to the laboratory in groups of four players each. Players were then subjected to a high-intensity fitness training session of 15 minutes (intervention). Exactly three minutes after the fitness session a 20 min CWT recovery session for the experimental group and 20 minutes of PAR for the control group were completed. The RESTQ-Sport was filled in again on the morning of the third day (post-recovery), 48 hours after the first completion of the RESTQ-Sport. The different morning measurements were repeated at exactly the same time of day so as to minimise the effects of circadian variations on the different physiological and psychological responses.

Measuring instruments

Demographic and general information questionnaire

Demographic and personal information of players were collected by means of the above-mentioned questionnaire. The following information was also obtained by means of the questionnaire: players' ages, training habits, injury incidents, competing levels and best performances.

Anthropometric measurements

The following anthropometric components were determined according to the protocols of the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart, Marfell-Jones, Olds, & De Ridder, 2011) to describe the specific cohort of rugby players. Body mass was recorded to the nearest 0.1 kg, using a calibrated BFW 300 Platform scale (Adam equipment Co. Ltd., U.K.) and body stature to the nearest 0.1 cm, using a Harpenden portable stadiometer

(Holtain Ltd., U.K.). Measurements were performed twice by a Level 2 ISAK certified Anthropometrist at the start of each testing session.

Recovery stress states

The RESTQ-Sport of Kellmann and Kallus (2001) is an instrument that systematically reveals the recovery stress states of athletes. The RESTQ-Sport consists of the following scales:

Table 4.1: The subscales of the RESTQ-Sport

General stress subscales:	General recovery subscales:
General stress	Success
Emotional stress	Social recovery
Social stress	Physical recovery
Conflicts/Pressure	General well-being
Fatigue	Sleep quality
Lack of energy	
Physical complaints	
Sport-specific stress subscales	Sport-specific recovery activity subscales
Disturbed breaks	Being in shape
Emotional exhaustion	Personal accomplishment
Injury	Self-efficacy
	Self-regulation

The RESTQ-Sport assesses potentially stressful and restful events and their subjective consequences during the past three days/nights. According to Kellmann and Kallus (2001), Cronbach alphas of above 0.7 were found for most of the scales within a month of testing, showing good internal consistency as well as test-retest reliability. A more recent study of Nederhof, Brink, and Lemmink, (2008) also showed that the RESTQ-Sport had sufficient reliability and validity (> 0.6) for use in sports practice and research. In a study of forty-one male university rugby players (mean age: 21.87 ± 1.39 years) acceptable Cronbach alphas of between 0.58 and 0.88 were calculated for 15 of the 19 subscales (Grobbelaar, Malan, Steyn, & Ellis, 2010).

Fitness session (Intervention)

A 10Hz GPS (Minimax V2.4, Catapult Sports, Victoria, Australia), was fitted to each player to record distances covered during execution of the session. Players completed a 15-minute, high-intensity fitness session on the rugby field while wearing rugby boots under the supervision of a qualified Sport Scientist with more than 10 years of experience in the Sport Science field. The fitness session consisted of two rugby-simulating drills that targeted both the aerobic and anaerobic energy systems as well as activities required in rugby (tackling, sprinting, accelerating and decelerating). Players firstly sprinted a certain distance (forwards: 30 m and backs: 32.5 m) while changing direction once within 15s for 10 times, interspersed by 15s of active rest (jogging). Secondly, players completed a 5 m sprint followed by a tackle, a sprint back and then a 20 m sprint to a marker and back within a 30s time limit. Players rested passively for 30s between six sets. Forwards and backs covered 1820 ± 11 m and 1923 ± 4 m on average, respectively during the fitness session.

Blood lactate measurement

Capillary blood samples were taken exactly 3 minutes after completion of the fitness session and used to analyse blood lactate by means of a Simplified Blood Lactate Test Meter (Lactate Pro LT-1710, Arkray Factory Inc., KDK Corporation, Shiga, Japan). The Lactate Pro Lactate Test Meter is a valid ($r = 0.975-0.993$) and reliable instrument for measuring blood lactate (Medbø, Mamen, Olsen, & Evertsen, 2000). The lactate test meter was calibrated according to the manufacturer's specifications at the beginning of the test day. A numeric result was displayed *via* an easy to read, large LCD screen within 60s after the blood sample had been drawn. Blood lactate was measured to ensure that the fitness session taxed the anaerobic glycolytic energy system and caused exhaustion.

Recovery sessions

Contrast water therapy (CWT)

During this recovery technique players were required to submerge themselves in a warm water pool, which was regulated at a temperature of $38 \pm 1^\circ\text{C}$ up to their umbilicus for a period of 3 min while standing still, followed by a quick transfer within 10s to an adjacent cryotherapy bath ($8 \pm 1^\circ\text{C}$) where they had to submerge themselves up to their umbilicus for 1 min. This 4-minute regimen was completed five times so that the total duration of the recovery period was 20 min. Several researchers have deemed the ratios of 3:1 to 4:1 for the duration of warm and cold water

immersions to be effective for acute recovery of participants (Higgins & Kaminski, 1998; Wilcock, Cronin, & Hing, 2006).

Passive recovery (PAR)

The control group was subjected to PAR during which they had to stay seated, fully clothed, for the whole 20 minute period in a laboratory, of which the temperature was regulated at 24°C.

Statistical analysis

The Statistical Data Processing Package (SPSS) for Windows (Version 22.0.0) was used to process data. Firstly, descriptive statistics (standard deviations, mean, minimum and maximum values) were reported for all variables measured during the different testing opportunities. Secondly, Wilcoxon Signed Rank Test was performed to determine the significant differences in the RESTQ-Sport general stress, general recovery, sport-specific stress and the sport-specific recovery activity subscales between the pre-fitness and post-recovery results within each group (PAR and CWT). This was followed by the calculation of non-parametric effect sizes to determine the practical significance of changes in groups. Effect sizes were calculated by dividing the z-scores that SPSS produces by the number of total observations (Field, 2007). Effect sizes of around 0.1, 0.3 and 0.5 were interpreted as small, medium and large respectively (Field, 2007). Next, Levene's test was performed for each of the variables to assess the equality of variances between groups (Gastwirth, Gel, & Miao, 2009). However, due to the fact that Levene's test revealed no significant F-values the analysis of covariance (ANCOVA) (with adjustment for baseline values) was performed to identify significant differences in the RESTQ-Sport subscale scores between the PAR and CWT groups. The level of significance was set at $p \leq .05$.

Results

Changes in RESTQ-Sport subscales from pre-fitness to post-recovery time periods

Table 4.2: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport general stress and recovery subscales between the pre-fitness and post-recovery time periods of the control group (PAR)

RESTQ subscales	N	Pre-anaerobic		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
General stress subscale	11	1.38	0.72	1.34	0.80	0.41	0.17[#]
General stress	11	1.14	0.98	1.45	1.21	0.20	0.28 [#]
Emotional stress	11	1.18	1.06	1.14	1.03	0.71	0.08 [#]
Social stress	11	1.77	0.96	1.18	0.96	0.05 [*]	0.41 ^{##}
Conflict/Pressure	11	1.77	1.08	1.91	1.14	0.96	0.01 [#]
Fatigue	11	1.77	1.03	1.82	1.21	0.89	0.03 [#]
Lack of energy	11	1.00	0.63	1.32	0.68	0.02 [*]	0.50 ^{###}
Physical complaints	11	1.05	0.72	0.59	0.63	0.03 [*]	0.45 ^{##}
General recovery subscale	11	2.92	0.91	3.13	0.78	0.14	0.32^{##}
Success	11	2.86	1.12	2.82	0.68	0.89	0.03 [#]
Social recovery	11	3.14	1.47	3.18	1.45	0.91	0.02 [#]
Physical recovery	11	2.50	0.91	2.64	0.78	0.55	0.13 [#]
General well-being	11	2.82	1.01	3.14	1.05	0.20	0.28 [#]
Sleep quality	11	3.50	1.30	3.86	1.38	0.32	0.21 [#]

* Statistically significant ($p \leq .05$); # Small effect size ~ 0.1 , ## Medium effect size ~ 0.3 , ### Large effect size ~ 0.5

Tabulated results of the control group show that social stress and physical complaints were the only RESTQ-Sport subscales that experienced statistically ($p < .05$) and medium practically significant ($d \sim 0.3$) decreases from pre-fitness to post-recovery time periods. Only the lack of

energy subscale showed a statistically ($p < .05$) and a large practically significant ($d \sim 0.5$) increase from the pre-fitness to post-recovery time periods. Although non-significant, the general recovery subscale showed a medium practically significant ($d \sim 0.4$) decrease in values over the 48 hour recovery period. Values of all other subscales remained more or less the same over the last-mentioned time period.

Table 4.3: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport sport-specific stress and recovery activity subscales between the pre-fitness and post-recovery time periods of the control group (PAR)

RESTQ subscales	N	Pre-anaerobic		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
Sport-specific stress subscale	11	1.58	1.10	1.54	0.67	0.77	0.06[#]
Disturbed breaks	11	1.64	1.27	1.16	0.82	0.01 [*]	0.55 ^{###}
Emotional exhaustion	11	1.34	1.08	1.55	0.75	0.32	0.21 [#]
Injury	11	1.77	1.21	1.91	1.24	0.79	0.06 [#]
Sport-specific recovery activity subscale	11	2.80	0.59	2.70	0.68	0.08	0.38^{##}
Being in shape	11	3.30	1.21	2.61	0.92	0.01 [*]	0.55 ^{###}
Personal accomplishment	11	2.13	0.65	2.32	0.94	0.83	0.05 [#]
Self-efficacy	11	3.55	1.17	3.16	0.74	0.15	0.31 ^{##}
Self-regulation	11	2.89	1.14	2.73	0.88	0.28	0.23 [#]

* Statistically significant ($p \leq .05$); # Small effect size ~ 0.1 , ## Medium effect size ~ 0.3 , ### Large effect size ~ 0.5

The rest of the RESTQ-Sport subscale scores show that disturbed breaks and being in shape displayed statistically ($p < .05$) and practically significant ($d \sim 0.5$) decreases from pre-fitness to post-recovery time periods. The sport-specific recovery activity and self-efficacy subscale

displayed medium practically significant ($d \sim 0.3$) reductions in values over the 48 hour recovery period. All other subscale values stayed more or less the same over the 48-hour period.

Table 4.4: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport general stress and recovery subscales between the pre-fitness and post-recovery time periods of the experimental group (CWT)

RESTQ subscales	N	Pre-anaerobic		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
General stress subscale	12	1.36	0.42	1.49	0.53	0.19	0.27[#]
General stress	12	0.96	0.66	1.17	0.89	0.46	0.15 [#]
Emotional stress	12	1.25	0.50	1.67	0.58	0.05 [*]	0.39 ^{##}
Social stress	12	1.54	0.62	1.67	0.72	0.52	0.13 [#]
Conflict/Pressure	12	1.58	0.63	1.46	0.66	0.59	0.11 [#]
Fatigue	12	1.38	0.74	1.67	0.65	0.30	0.21 [#]
Lack of energy	12	1.58	0.63	1.92	0.70	0.16	0.29 [#]
Physical complaints	12	1.25	0.78	0.88	0.68	0.07	0.37 ^{###}
General recovery subscale	12	3.57	0.57	3.49	0.52	0.47	0.15[#]
Success	12	3.17	0.72	2.79	1.05	0.11	0.33 ^{###}
Social recovery	12	4.13	0.88	4.25	0.92	0.37	0.18 [#]
Physical recovery	12	3.21	1.03	3.13	0.53	0.67	0.09 [#]
General well-being	12	3.54	0.78	3.71	0.62	0.23	0.24 [#]
Sleep quality	12	3.79	0.69	3.58	0.85	0.30	0.21 [#]

* Statistically significant ($p \leq .05$); # Small effect size ~ 0.1 , ## Medium effect size ~ 0.3 , ### Large effect size ~ 0.5

For the experimental group, the emotional stress subscale was the only RESTQ-Sport subscale that displayed statistical ($p < .05$) and medium practically significant ($d \sim 0.3$) increases from pre-fitness to post-recovery time periods. Physical complaints and success subscales showed

medium practically significant ($d \sim 0.3$) reductions in values over the 48-hour recovery period. All other subscale values remained more or less the same over the last-mentioned time period.

Table 4.5: Descriptive statistics, Wilcoxon Signed Rank Test and effect size results for differences in the RESTQ-Sport sport-specific stress and recovery activity subscales between the pre-fitness and post-recovery time periods of the experimental group (CWT)

RESTQ subscales	N	Pre-anaerobic		Post-recovery		p-value	d-value
		Mean	SD	Mean	SD		
Sport-specific stress subscale	12	1.33	0.60	1.23	0.62	0.17	0.28[#]
Disturbed breaks	12	1.21	0.70	1.10	0.76	0.37	0.18 [#]
Emotional exhaustion	12	0.94	0.58	0.88	0.69	0.68	0.09 [#]
Injury	12	1.85	0.90	1.71	1.01	0.28	0.22 [#]
Sport-specific recovery activity subscale	12	3.24	0.74	3.23	0.83	0.96	0.01[#]
Being in shape	12	3.44	0.80	3.48	0.73	0.63	0.10 [#]
Personal accomplishment	12	2.77	1.06	2.75	1.19	0.95	0.01 [#]
Self-efficacy	12	3.40	0.75	3.60	0.90	0.04 [*]	0.42 ^{##}
Self-regulation	12	3.35	1.02	3.10	1.29	0.25	0.23 [#]

* Statistical significance ($p \leq .05$); Effect sizes of 0.1 = small (#), 0.3 = medium (##), 0.5 = large (###)

Only self-efficacy revealed a statistical ($p < .05$) and medium practically significant ($d \sim 0.4$) increase from the pre-fitness to post-recovery time period. All other subscale values remained more or less the same over the last-mentioned time period.

Comparisons of RESTQ-Sport subscale changes between the CWT and PAR groups

Table 4.6: Results of the ANCOVA for the RESTQ-Sport subscale changes between the PAR and CWT groups

RESTQ Subscales	F-value	P-value
General stress subscale	1.01	0.33
General stress	0.08	0.78
Emotional stress	6.73	0.02*
Social stress	0.68	0.42
Conflicts/Pressure	0.02	0.89
Fatigue	3.95	0.06
Lack of energy	3.01	0.10
Physical complaints	0.07	0.80
General recovery subscale	0.00	0.99
Success	4.41	0.05*
Social recovery	0.04	0.84
Physical recovery	1.18	0.29
General well-being	0.30	0.59
Sleep quality	0.40	0.54
Sport-specific stress subscale	7.74	0.01*
Disturbed breaks	0.83	0.37
Emotional exhaustion	3.96	0.06
Injury	0.86	0.37
Sport-specific recovery activity subscale	7.83	0.01*
Being in shape	0.43	0.52
Personal accomplishments	0.98	0.34
Self-efficacy	5.97	0.03*
Self-regulation	2.32	0.14

* Statistical significance ($p \leq .05$)

From Table 4.6 it is clear that the emotional stress, success, self-efficacy sport-specific stress and recovery activity subscales showed significant differences ($p < .05$) between the PAR and CWT

groups. Emotional stress and success subscales showed a practically significant negative trend in the CWT group whereas both subscale values stayed more or less similar in the PAR group. On the other hand, self-efficacy showed statistically and practically significant positive changes in the CWT group compared to the PAR group whose values showed a practically significant decrease (negative change). The CWT group also experienced a significant decrease in the sport-specific stress subscale when compared to the PAR whose values stayed more or less the same. However, the sport-specific recovery subscale showed a practically significant decline in the PAR group compared to the CWT group.

Discussion

To the researchers' knowledge this is the first study to investigate and compare the effects of CWT and PAR on the subscales of the RESTQ-Sport after an exercise intervention in rugby players. Surprisingly, only the following RESTQ-Sport subscale changes showed significant differences between the PAR and CWT groups over the 48-hour period: emotional stress, success, self-efficacy, sport-specific stress, and recovery. However, self-efficacy as well as sport-specific stress and recovery were positively affected by CWT compared to PAR whereas PAR was more effective in causing positive changes in emotional stress and success compared to CWT over the 48-hour period. Nevertheless, intra-PAR group changes revealed that social stress, physical complaints and disturbed breaks were all positively ($p \leq .05$; $d \sim 0.4-0.5$) affected during the recovery period. Similarly, the general recovery subscale showed a practically significant improvement ($d \sim 0.32$) in values over the 48-hour period. Despite positive changes, significant negative changes were observed for being in shape ($p = .01$; $d \sim 0.55$) and lack of energy ($p = .02$; $d \sim 0.5$) whereas sport-specific recovery ($d \sim 0.38$) and self-efficacy ($d \sim 0.31$) subscales showed practically significant negative changes over the 2-day period. Then again, CWT caused a significant positive change from pre-fitness to post-recovery time periods for self-efficacy ($p = .04$; $d \sim 0.42$) and physical complaints ($d \sim 0.37$). In contrast, emotional stress ($p = .05$; $d \sim 0.39$) and success ($d \sim 0.33$) showed significant negative changes over the same time period. Nevertheless, the reader must realise that in cases where PAR or CWT had the desired recovery effect on the RESTQ-Sport subscales of players, post-recovery values would be more or less similar to those of pre-fitness values and would therefore *not* obtain statistical or practically significant differences. This would mean that players' subscale values returned to levels that were observed before execution of the exhausting fitness session.

In view of the last-mentioned explanation, it is clear that despite the negative influence of PAR on the above-mentioned subscale scores, PAR resulted in the recovery of the majority of general stress (6 out of 7) and all of the general recovery subscales (5 out of 5). Furthermore, the sport-specific stress-related subscales were all positively influenced by PAR (3 out of 3) whereas an equal number of sport-specific recovery-related subscales were negatively (2) and positively influenced (2) over the 48-hour recovery period. However, as mentioned before the sport-specific recovery subscale showed a practically significant downward trend from the pre-fitness to the post-recovery period. Therefore, although PAR positively influenced the sport-specific stress subscale score, it had a negative influence on the sport-specific recovery subscale score.

In the present study PAR had negative effects on being in shape, self-efficacy and sport-specific subscales, which are in line with findings of Hausswirth et al. (2011) who reported no significant changes in pain or perceived tiredness in well-trained runners 48h after exercise. Furthermore, another study reported that cyclists' legs felt heavy and stiff between cycling trials (Lane & Wenger, 2004). In contrast to the present study, Rey, Lago-Peñas, Casáis, and Lago-Ballesteros, (2012) reported a significant increase ($p = .05$) in perceived muscle soreness in professional soccer players 24h after specific soccer training despite the use of PAR (20 min sitting on a bench) as a recovery technique, whereas PAR in our study had a positive effect in the physical complaints. Another study reported significant ($p = 0.00$) increases in the perceived recovery score after high-intensity treadmill running following PAR in male athletes (Brophy-Williams et al., 2011), which are similar to present study results that PAR led to positive changes in physical complaints, physical recovery and general well-being subscales. Our study also showed that PAR positively influenced the general recovery subscale of players since no statistically or practically significant difference was found between the pre-fitness and post-recovery values.

However, in general, studies that have thus far investigated the effects of PAR on the recovery of athletes are in contrast to the results of this study. For example, Hausswirth et al. (2011) observed that neither pain nor perceived tiredness of nine well-trained runners was reduced by PAR (seated for 30 min) 48h after exercise, while others indicated that PAR did not have any significant effects on muscle pain or recovery following soccer training and a DOMS-inducing leg press protocol (Tessitore et al., 2007; Vaile et al., 2007). Moreover, Morton (2007) found that PAR had no effect on the plasma lactate clearance rate of athletes, which meant that metabolic recovery was not influenced by PAR post-exercise. In addition, researchers observed no

significant decreases in perceived fatigue (De Nardi et al., 2011; Elias, Varley, Wyckelsma, McKenna, Minahan, & Aughey, 2012; Gill et al., 2006) or muscle soreness following PAR after a repeated sprint ability test in American Football players (Elias et al., 2012) and after 80 minutes of team sport exercise in team athletes (Ingram et al., 2009). PAR also had a non-significant ($p > .05$) effect on fatigue in male state-level hockey players after exercise (Sayers et al., 2011).

Several possible reasons could be provided for differences in results between studies. For example, studies differ with regard to the psychometric instruments used with some measuring self-ratings of muscle soreness by making use of a 10-point Likert Scale (Ingram et al., 2009) while others made use of a Visual Analogue Scale (Vaile et al., 2007) or a 7-point Likert Scale (Robey, Dawson, Goodman & Beilby, 2009). Different measurement instruments and scales would give rise to unique results. Furthermore, the timing of measurements may also influence results with some researchers measuring variables immediately before performance tests, immediately after execution of an exercise protocol or immediately, 24-, 48- or 72h post-recovery (Vaile et al., 2007). In contrast, our study made use of the RESTQ-Sport questionnaire for athletes, which was completed 48h post-recovery. As far as the researcher knows, no other study examined recovery of athletes by using the RESTQ-Sport questionnaire. The uniqueness of this study makes it difficult to compare study results with those of other studies.

Participants' prior belief regarding the effectiveness or ineffectiveness of a specific recovery technique may also have influenced the psychological benefits derived from the technique (Stacey et al., 2010). It is therefore possible that prior belief or perceptions about the effectiveness of PAR as a recovery technique played a role in the more positive, perceived response that participants in this study showed compared to participants of other studies.

Methodological differences could also serve as a possible reason for differences in the outcome of PAR between our study and those of others. For example, participants in Morton's study (2007) had to lie stationary on a recovery bed for 30 min, while Sayers et al. (2011) expected their participants to stay seated in an upright position with their legs outstretched on an adjustable massage table for 12 min. Others required participants to stay seated on a bench for 9 min, 15 min or 30 min (Hauswirth et al., 2011; Vaile et al., 2007) compared to this study where participants had to be seated for 20 min at a room temperature of 24°C.

In addition, exercise interventions used to cause fatigue differed between studies. For example, Hausswirth et al. (2011) made use of a simulated trial run of 48 min and Tessitore and co-workers (2007) of a program of 100 min that consisted of a 15 min warm up, 65 min of individual, group and team technical drills and a circuit of 20 min. Other exercise protocols included high-intensity cycling (Sayers et al., 2011), a team sport exercise simulation (Ingram et al., 2009), high-intensity stair climb running (Robey et al., 2009) and a delayed onset of muscle soreness-inducing (DOMS) leg press protocol consisting of 5 x 10 eccentric contractions at 140% of one repetition maximum (Vaile et al., 2007). However, our study made use of a 15-minute fitness session that consisted of two rugby-simulating drills. Differences in the duration and type of interventions between this and other studies as well as differences in the timing of measurements, may lead to different physiological and psychological responses to PAR. Sessions that lead to less pain and muscle soreness may lead to a heightened sense of well-being after recovery compared to sessions that lead to more pain and muscle soreness (Stacey et al., 2010). Therefore, the intensity and type of muscle contractions performed during the fatiguing exercise session may influence the outcome of the recovery technique such as PAR. All of these factors may contribute to differences between studies in recovery technique responses.

Similarly to PAR, CWT resulted in the recovery of all general stress subscale (6 out of 7) values except for physical complaints that showed a practically significant worsening from pre-fitness to post-recovery. Equally, CWT led to the recovery of all general recovery subscales (4 out of 5) except for success that showed a medium practically significant decline. In contrast, all the sport-specific stress (3 out of 3) and recovery activity subscales (4 out of 4) recovered over the 48-hour period due to CWT. Self-efficacy showed a practically significant increase from the pre-fitness to the post-recovery period whereas a practically significant improvement was seen for physical complaints.

In summary, results of the present study showed that CWT led to positive changes in fatigue, lack of energy, physical recovery, emotional exhaustion, injury and general well-being subscales. Similar studies that have thus far examined the possible recovery benefits of CWT, observed a significant decrease ($p < .00$) in the ratings of fatigue after high-intensity cycling (Sayers et al., 2011). CWT also led to a significant decrease ($p < .05$) in muscle soreness 24h after a simulated team sport exercise of 80 min (Ingram et al., 2009) and a significant increase ($p < .01$) in the return of perceived arm muscle soreness after eccentric elbow extensions in male and female

volunteers (Kuligowski et al., 1998). CWT of more than 10 minutes also caused an accelerated recovery (due to a significant increase in blood lactate clearance) after 4 x 30s Wingate tests in participants (Morton, 2007). Furthermore, CWT led to a significant decrease ($p < .01$) in the perception of muscle pain after 7 sets of 10 eccentric leg press repetitions in strength-trained males (Vaile et al., 2008).

The present study also showed that CWT had a positive effect on being in shape, personal accomplishment, self-efficacy and self-regulation subscales. Similar results were reported by Ingram et al. (2009) who also found significant decreases ($p < .05$) in muscle soreness due to CWT 24h post-exercise following 80 min of a simulated team sport exercise. Moreover, one popular theory suggests that the vasodilatation and vasoconstriction caused by alternating heat and cold, results in a pumping action that increases blood flow and facilitates recovery (Kuligowski et al., 1998), which may serve as a probable reason for the positive effects of CWT. However, some authors reported that CWT does not produce intramuscular temperature changes required to induce a “pump” effect, which cast a shadow of doubt on the validity of this theory (Higgins and Kaminski, 1998).

The non-significant changes between the pre-fitness and post-CWT periods suggest that fatigue and physical recovery recovered back to baseline values over the 48-hour period. Studies that compared the post-exercise and CWT-intervention values with each other, found a non-significant decrease in the perception of fatigue, discomfort and stress ($p > .05$) after exhaustive treadmill runs in male volunteers (Coffey et al., 2004). De Nardi et al. (2011) also observed that CWT led to a non-significant reduction in perceived fatigue of young soccer players over a 4-day period which consisted of soccer-specific training, performance tests and small-sided games for a total of 140 min per day. In addition, CWT led to non-significant differences in muscle soreness after stair climb running in club and junior elite rowers (Robey et al., 2009) as well as no significant differences in perceived leg muscle pain (VAS) ($p > .05$) after a DOMS-inducing leg press protocol in recreational athletes (Vaile et al., 2007).

Differences in measurement protocols and times between studies complicate the direct comparison of results. For example, participants in the study of Coffey et al. (2004) were subjected to water immersions at temperatures of 10°C and 42°C for 60 and 120s, respectively up to a total immersion time of 15 min after exhausted treadmill runs. Others applied water

immersions at average temperatures of 12.8°C for one min and 38.9°C for 3 min, respectively for a total duration of 24 min after eccentric elbow extensions (Kuligowski et al., 1998). On the other hand, Morton (2007) used temperatures of 12°C for 1 min and 36°C for 4 min for a total duration of 30 min after high-intensity cycling. In the present study, CWT consisted of immersions in water of 8°C for 1 min and 38°C for 3 min for a total duration of 20 min. Furthermore, water immersion depths varied with some participants that had to immerse themselves up to the level of the jugular notch (Sayers et al., 2011), the anterior superior iliac spine (Coffey et al., 2004) or the gluteal fold (Morton, 2007) while participants in this study immersed themselves up to the umbilicus.

Possible reasons for the positive influence of CWT on the above-mentioned RESTQ-Sport subscales include the following: The depth of immersion will determine the degree of the hydrostatic pressure that the body experiences, with pressure that increases as immersion depth increases (Kaczmarek et al., 2013 Wilcock et al., 2006). According to Cochrane (2004) the combined effects of hydrostatic pressure and low water temperatures result in muscular and vascular compression which would reduce swelling, inflammation and oedema, due to the removal of waste products such as blood lactate and creatine kinase. A reduction in swelling, inflammation and oedema may lead to the perception of less pain (Kuligowski et al., 1998). Furthermore, the difference in the hydrostatic pressure of water over the immersed body may cause a decrease in systematic peripheral and vascular resistance and a subsequent increase in muscular blood flow (Sayers et al., 2011; Wilcock et al., 2006). Then again, a higher blood flow will allow for an increased supply of oxygen (Cochrane, 2004) which would also lead to better recovery of the body's physiological systems. Water immersion also leads to relaxation and reduces perceptions of fatigue and soreness (Wilcock et al., 2006). The buoyancy of the body in water decreases the effects of gravity on the musculoskeletal system which may lead to greater relaxation of gravitational muscles and a subsequent reduction in perceived fatigue (Wilcock et al., 2006). Therefore, CWT hastens blood lactate clearance, results in lighter and less tight muscles with a feeling of mental freshness, and improves the subjective perception of recovery (Morton, 2007).

In view of current literature findings, researchers hypothesised that CWT will lead to significantly more positive changes ($p \leq .05$) in RESTQ-Sport subscales among university-level rugby players than PAR. However, despite this hypothesis only self-efficacy as well as sport-

specific stress and recovery were positively affected by CWT compared to PAR whereas PAR was more effective in causing positive changes in emotional stress and success compared to CWT over the 48-hour period. Studies that have thus far compared CWT to PAR in a sport context found that CWT was significantly more beneficial, especially in decreasing ratings of fatigue (Sayers et al., 2011), perception of muscle pain (Vaile et al., 2008) and muscle soreness 24 h post-exercise (Ingram et al., 2009). Furthermore, studies reported accelerated recovery (due to a significant increase in blood lactate clearance) recovery after 4 x 30s Wingate tests (Morton, 2007), as well as a significant decrease ($p < .01$) in the perception of muscle pain after eccentric leg press exercises (Vaile et al., 2008) following a CWT protocol. Kinugasa and Kilding (2009) found that CWT increased perceived recovery in soccer players, as players' legs felt lighter following match-play due to CWT when compared to PAR, which is similar to the present study where CWT led to more positive changes in the sport-specific recovery subscale. Sayers et al. (2011) indicated that CWT reduced the perception of fatigue ($p < .00$) and delayed onset of muscle soreness (DOMS) in 14 high-performance field hockey players compared to PAR after execution of a Wingate test (maximal effort cycle ergometer test).

Although the current study design did not allow researchers to explain reasons underlying the finding that CWT caused a significantly more positive change in only three RESTQ-Sport subscales among university-level rugby players compared to PAR, Calder (2010) suggested that recovery interventions may be more effective when an athlete's fatigue is cumulated over consecutive days, several sessions a day or through extended competition periods. It is possible that the use of a single, 15-minute long fitness session was not effective to induce an adequate amount of fatigue to amplify the recovery effects of CWT and PAR. Another factor which might have influenced players' responses to CWT is the possible discomfort that players may have experienced due to the low temperature of cold water immersions during CWT. This is a particular concern in cases where some players are more sensitive to cold than others (Sayers et al., 2011). It is especially the general stress (physical complaints) and sport-specific recovery subscales (being in shape) that may be influenced by the negative responses of players due to cold immersions. In addition, Stacey et al. (2010) stated that participants' who feel less pain and muscle soreness have a heightened sense of well-being after recovery. It is therefore possible that participants responded differently and experienced different levels of pain and soreness due to the fitness session compared to others, which would also influence the outcome of recovery

interventions. Consequently, researchers should rather look at individual player's responses when investigating the effects of various recovery techniques than combining players' results.

External stressors that are not related to training may also have influenced participants' responses to the RESTQ-Sport. For example, all players who participated in this study were full-time university students who played rugby on a part-time basis. Stressors related to studying and being a full-time student as well as playing amateur rugby would possibly influence RESTQ-Sport responses. Furthermore, due to the nature of the study, participants knew beforehand what recovery intervention they would be subjected to. Prior beliefs about the effectiveness of one recovery technique compared to another technique may have influenced subscale responses that are for example related to pain or fatigue (Wager, 2005). Furthermore, even though the benefits of using CWT for the psychological recovery of athletes have been proven, more scientific evidence is needed to support the use of CWT as a psychological recovery technique (Barnett, 2006).

Conclusion

Study results showed that PAR and CWT affected the subscale scores of the RESTQ-Sport differently in rugby players, with self-efficacy as well as sport-specific stress and recovery that were positively affected by CWT compared to PAR whereas PAR was more effective in causing positive changes in emotional stress and success compared to CWT over the 48-hour period. However, intra-group results showed that CWT and PAR had beneficial recovery effects on the majority of RESTQ-Sport subscales in rugby players over the evaluation period. Therefore, findings from this study provide important information with regard to the area of team sport recovery. However, future research is needed to verify the effectiveness of CWT and PAR for the psychological and physiological recovery of athletes, especially after execution of high-intensity exercise.

Despite the usefulness of study findings, the use of subjective methods to monitor the possible recovery benefits of different recovery techniques has some limitations, mainly because it requires honest responses and a thorough understanding of the instrument by athletes (Freitas, Nakamura, Miloski, Samulski, & Bara-Filho, 2014). Furthermore, although the inclusion criteria for study participation ensured that the participant group was homogeneous, it limited the sample size, which may have affected the statistical significance of differences between groups. Another

point to consider is that some researchers recommend that the RESTQ-Sport be utilised as an individual tool to monitor performance (Kellmann & Kallus, 2001). What this means, is that it would be better to monitor each player's individual response to different recovery techniques rather than making use of group averages to determine overall responses. This is especially a valid point, seeing that small increases in a single athlete's physiological and psychological response to recovery techniques can have a relevant impact on competition performances (Tessitore et al., 2007). In addition, players' RESTQ-Sport results may allow coaches and sport conditioners to detect stress and negative affective states in advance in order to prevent overtraining, and facilitate optimal training and sport performance (Nicholls et al., 2009).

Lastly, a more in-depth evaluation of players' psychological states is required to determine which recovery techniques are the most beneficial for individual player's recovery. Future research should therefore give more attention to this aspect. This point is accentuated by the fact that psychological factors influence individuals' performances and forms a crucial part of athlete's make-up (Tessitore et al., 2007).

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CHAPTER 5

5. Summary, conclusions, limitations and recommendations

5.1 Summary

5.2 Conclusions

5.3 Limitations and recommendations

5.1 Summary

The purpose of this study was firstly to determine the differences in the 48-hour post-recovery effects of PAR and CWI on the subscales (General Stress, General Recovery, Sport-Specific Stress and Sport-Specific Recovery) of the RESTQ-Sport in university-level rugby players, and secondly to determine differences in the 48-hour post-recovery effects of PAR and CWT on the subscales of the RESTQ-Sport in university-level rugby players. Chapter 1 provided the problem statement, the objectives and hypotheses of the study as well as the structure of the dissertation.

Chapter 2 consisted of a literature overview titled “The effects of cold water immersion, contrast water therapy and passive recovery on the stress and recovery of rugby players”. The purposes of this review were firstly to describe the physical, physiological and psychological demands of rugby; secondly to discuss the characteristics and causes of overtraining and burnout; thirdly to define the term recovery and explain the need for recovery in sport; fourthly to describe CWI, CWT and PAR as well as discuss findings with regard to the physiological and psychological effects of these recovery techniques on especially sport participants and lastly, the fifth aim was to discuss different psychometric instruments used in the assessment of stress and recovery in sport participants.

From the literature review it is evident that rugby imposes high physiological and psychological demands on players, which are further exacerbated by the demanding competition regime that players face, the short recovery durations between matches and intense training sessions. High psychological demands may lead to an imbalance between training stress and recovery which

over time may cause overtraining and burnout. In order to control for factors that affect and contribute to overtraining, resting or reduced training for a period of time (weeks or months) or an improvement in the quality of recovery is necessary. It is therefore important to implement effective recovery strategies especially during periods when training loads are increased and athletes experience fatigue.

The most popular recovery techniques currently being used by athletes are CWI, CWT and PAR. However, research thus far is very conflicting. Researchers indicated that CWI and CWT can decrease the perception of muscle soreness and fatigue, as well as increase the perception of recovery post-exercise, whereas certain contradictory research indicated that CWI and CWT led to a non-significant decrease in the last-mentioned psychological factors. With regard to PAR, most research suggests that PAR is ineffective in reducing certain psychological factors such as perceived muscle soreness and fatigue. One study formed an exception by reporting significant decreases in the perceived recovery score after high-intensity treadmill running following PAR, although some researchers do not recommend the use of PAR as a post-exercise recovery technique.

Research on the psychological benefits of CWI post-exercise revealed that CWI significantly reduced perceived muscle soreness, increased the perception of recovery and reduced the perception of fatigue. These changes were observed when CWI temperatures of between 10 and 15°C were used and the application times were between 5 and 15 minutes. In contrast, some researchers found CWI to be inefficient in significantly reducing the perception of muscle soreness following competitive simulation games. Despite above-mentioned findings which suggest that CWI protocol temperatures of between 8 and 15 °C for durations of between 4 and 20 minutes seem to be the most effective in causing positive changes in the psychological and physiological recovery of athletes, wide variations in results, CWI temperatures and durations render it difficult to fix specific CWI protocol guidelines for athletes. More research is therefore required to establish guidelines for the most effective CWI protocols for specifically team sport participants such as rugby players.

CWT exposure temperatures ranged between 38 and 40°C as well as 8 and 15°C and total exposure times between 9 and 24 minutes. These CWT protocols led to decreases in the perception of fatigue, the perception of muscle soreness and muscle pain, as well as a significant

decrease in ratings of fatigue after exercise. Similar to CWI related studies, CWT protocol application times varied considerably between studies with total application times that ranged from 6 to 25 minutes and consisted of 1 to 2 minutes of CWI and 2 minutes of hot water immersion.

However, researchers need to consider the reliability, validity and usefulness of psychometric instruments that can be used to evaluate athletes' psychological components and profile after the application of different recovery techniques. Although research suggests that the Daily Analysis of Life Demands for Athletes questionnaire (DALDA), The Profile of Mood States (POMS), The Stellenbosch Mood Scale (STEMS) and The Recovery-Stress Questionnaire of Athletes (RESTQ-Sport) are all instruments that can be used in this regard, the RESTQ-Sport is the only valid and reliable instrument for measuring the regularity of both psychological stress and recovery-associated activities. An instrument that allows researchers, sport practitioners and athletes to monitor factors that influence the stress-recovery balance may enable these groups of people to enhance the recovery process and maintain performance. Nonetheless, there is a shortage of scientific data that verifies the psychological benefits of different recovery techniques in elite athletes by making use of the RESTQ-Sport. Therefore, it can be recommended that in future researchers should focus more on the possible effects of CWI, CWT and PAR as viable recovery modalities on the RESTQ-Sport subscale results of especially team sport participants such as rugby players.

Chapter 3 comprises the first article which was compiled in accordance with the guidelines of the International Journal of Sport and Exercise Psychology and entitled: "The 48-hour post-exercise effects of passive recovery and cold water immersion on the subscales of the Recovery-Stress Questionnaire in rugby players". The purpose of this article was to determine the 48-hour post-exercise differences between the effects of PAR and CWI on the subscales of the RESTQ-Sport in university-level rugby players. A group of twenty-three u/21 university-level rugby players (age: 20.1 ± 0.4 years) of a South African university's Rugby Institute voluntarily participated in this study and were randomly assigned to either an experimental group (CWI) or a control group (PAR). Data were obtained by means of questionnaires aimed at gaining demographic and general information as well as information with regard to the recovery stress states of the participants. In this regard, the RESTQ-Sport was completed over two time periods, namely: early in the morning (pre-fitness) before execution of a high-intensity fitness session and again

on the morning of the third day (48h after the first completion of the RESTQ-Sport). The experimental group completed 20 minutes of CWI, whereas the control group recovered passively for the same time period. Descriptive statistics (standard deviations, mean, minimum and maximum values) were reported for all variables measured. A Wilcoxon Signed Rank Test was performed to determine the significant differences in the RESTQ-Sport subscales between the pre-fitness and post-recovery results within each of the groups (PAR and CWI). This was followed by the calculation of non-parametric effect sizes to determine the practical significance of changes in groups. Next, Levene's test was performed for each of the variables to assess the equality of variances between groups. In cases where Levene's test revealed a non-significant F-value the analysis of covariance (ANCOVA) (with adjustment for the baseline values) was performed to identify significant differences in the RESTQ-Sport subscale scores between the CWI and PAR groups. However, in cases where Levene's test revealed a significant F-value, the non-parametric ANCOVA was applied. The level of significance was set at $p \leq 0.05$.

Study results showed that PAR had positive influences on the following subscales: emotional stress, conflicts/pressure, fatigue, lack of energy, physical complaints, physical recovery, sleep quality, disturbed breaks, emotional exhaustion, injury and personal accomplishment. General stress, success, social recovery and general well-being were all subscales of which scores were negatively affected ($d > 0.3$) by PAR over the 48 hour period. Nevertheless, the major general stress and recovery subscale scores remained the same from pre-fitness to post-recovery which indicates that the desired recovery effect was achieved. Being in shape, self-efficacy and self-regulation all showed a practically significant ($d > 0.3$) downward trend from the pre-fitness to the post-recovery period. Results also showed that CWI had positive effects on the following subscales: general stress, social stress, and emotional stress, conflicts/pressure, and fatigue, lack of energy, physical complaints, disturbed breaks, emotional exhaustion and injury. Success, social and physical recovery were all subscales of which scores were negatively affected ($d > 0.3$) by CWI over the 48 hour period. Scores for the general stress and recovery subscales decreased significantly ($d = 0.37$; $d = 0.55$) from pre-fitness to post-CWI. Being in shape, personal accomplishment, self-efficacy and self-regulation showed a practically significant downward trend from the pre-fitness to the post-recovery period. Surprisingly, even though the CWI group displayed statistically and practically significant pre-fitness to post-recovery changes for a larger number of the RESTQ-Sport subscales compared to the PAR group, only sport-

specific recovery and self-efficacy showed a more pronounced significant decrease in the CWI-group compared to the PAR-group.

Chapter 4 consisted of the second article which was compiled in accordance with the guidelines of the Journal of Applied Sport Psychology and titled: “Differences between the 48-hour post-exercise effects of passive recovery and contrast water therapy on the subscales of the Recovery-Stress Questionnaire in rugby players”. The purpose of this study was to determine the 48-hour post-exercise differences between the effects of PAR and CWT on the subscales of the RESTQ-Sport in university-level rugby players. Exactly the same methodology as in article 1 was followed with the exception that the experimental group was subjected to CWT instead of CWI.

Results showed that PAR positively influenced social stress, physical complaints, emotional stress, conflicts/pressure, fatigue, success, social recovery, physical recovery, general well-being, sleep quality, disturbed breaks, emotional exhaustion, injury, self-regulation and personal accomplishment subscales. Self-efficacy showed a practically significant downward trend from the pre-fitness to the post-recovery period. However, the major sport-specific recovery subscales showed a practically significant downward trend from the pre-fitness to the post-recovery period. Therefore, although PAR positively influenced the major sport-specific stress subscale score, it had a negative influence on the sport-specific recovery subscale score. For the CWT-group, general stress, social recovery, physical recovery, general well-being, sleep quality, disturbed breaks, emotional exhaustion, injury, being in shape, personal accomplishment and self-regulation all showed positive changes from pre-fitness to post-recovery. Scores for the general stress and recovery subscales decreased significantly from pre-fitness to post-CWT. Despite all these intra-group changes, self-efficacy as well as sport-specific stress and recovery were the only RESTQ-Sport subscales that were positively affected by CWT compared to PAR whereas PAR was more effective in causing positive changes in emotional stress and success compared to CWT over the 48-hour period.

5.2 Conclusions

Conclusions drawn from this research are presented in accordance with the set hypotheses (Chapter 1):

Hypothesis 1: *Comparatively, CWI will have practically ($d \sim 0.3-0.5$) and statistically significant ($p \leq 0.05$) more 48-hour post-recovery effects on the RESTQ-Sport subscales of university-level rugby players, than PAR.*

Hypothesis 1 is only partly accepted, since the results of this study showed that only sport-specific recovery and self-efficacy showed a more pronounced significant decrease in the CWI-group compared to the PAR-group.

Hypothesis 2: *Comparatively, CWT will have practically ($d \sim 0.3-0.5$) and statistically significant ($p \leq 0.05$) more positive 48-hour post-recovery effects on the RESTQ-Sport subscales of university-level rugby players, than PAR.*

Hypothesis 2 is only partly accepted, since the results of this study showed that only self-efficacy as well as sport-specific stress and recovery were significantly more positively affected by CWT compared to PAR whereas PAR was more effective in causing positive changes in emotional stress and success compared to CWT over the 48-hour period.

Overall, study results suggest that compared to PAR, CWI and CWT only had significant better 48h-effects on the sport-specific stress and recovery as well as self-efficacy subscales of university-level rugby players whereas none of the general stress and recovery subscales benefited more from CWI or CWT compared to PAR. Therefore, despite the usefulness of the RESTQ-Sport Questionnaire in determining general stress and recovery among athletes, the researcher suggests that sport scientists, sport psychologists, coaches and players should rather focus on the sport-specific subscales when using this questionnaires to evaluate and monitor the stress and recovery profiles of university-level rugby players.

5.3 Limitations and recommendations

Although this study is the first to examine the different effects of CWI, CWT and PAR on the subscales of the RESTQ-Sport in university-level rugby players and provides sport scientists, sport psychologists, coaches and rugby players with some clarity regarding the efficacy of PAR, CWI and CWT as recovery interventions there are certain shortcomings that need to be considered when interpreting study results.

- Firstly, future research should make use of longer periods of exercise interventions when investigating the possible influence of different recovery techniques on the RESTQ-Sport subscales of players. A rugby game or full training session would probably serve as a better

and more sport-specific intervention to cause physiological and psychological fatigue than a fitness-session that makes use of rugby-specific drills and activities.

- Secondly, it can be recommended that players, coaches and practitioners rather use a combination of recovery techniques in order to ensure effective recovery of athletes.
- Thirdly, it is advisable to evaluate and consider individual players' unique physiological and psychological responses to recovery techniques when choosing the most effective technique for acute recovery between training sessions and matches. Furthermore, it probably would be of more value to monitor individual responses of each player to a specific recovery intervention over time in order to pick up subtle changes in RESTQ-Sport subscales which may have a positive impact on a player's performance. Consequently, researchers should rather look at individual player's responses over a long period of time when investigating the effects of various recovery techniques.
- Fourthly, the use of subjective methods to monitor the possible effect of recovery techniques has some limitations, as it requires honest responses and a thorough understanding of the instrument by athletes. Individual differences in effort capacity, external stressors not related to training and stress tolerance levels may also have influenced participants' responses to the RESTQ-Sport.
- Fifthly, the need for a homogeneous group of players, limited the sample size of this study, which affected the statistical significance of results. Future research should therefore aim to use bigger sample sizes to prevent outliers from influencing the significance of overall results.
- Lastly, a more in-depth evaluation of players' psychological states is required to determine which recovery techniques are the most beneficial for individual player's recovery. Future research should therefore give more attention to this aspect. This point is accentuated by the fact that psychological factors influence individuals' performances and form a crucial part of an athlete's make-up.

Appendices

Appendix A:	Informed consent
Appendix B:	Raw data card
Appendix C:	Questionnaire: Demographic and general information
Appendix D:	Questionnaire: Th Recovery-Stress Questionnaire (RESTQ-Sport)
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Appendix F:	Guidelines for authors: Journal of Applied Sport Psychology
Appendix G:	Proof of language editing

Appendix A: Informed consent



HREC Stamp

**PARTICIPANT INFORMATION LEAFLET AND CONSENT FORM FOR
PARTICIPANTS OF THE RUGBY RECOVERY PROJECT**

TITLE OF THE RESEARCH PROJECT:

**Effects of different recovery techniques on certain physical, motor performance,
psychological and haematological components in university-level rugby players**

REFERENCE NUMBERS: NWU-00201-14-A1

PRINCIPAL INVESTIGATOR:

Prof. Ben Coetzee

ADDRESS:

School for BRS
Building K21
North-West University
Faculty of Health Sciences
Potchefstroom
2522

CONTACT NUMBER: 0182991803

You are being invited to take part in a research project that forms part of several post graduate, master degree-studies. Please take some time to read the information presented here, which will explain the details of this project. Please ask the researcher any questions about any part of this project that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research entails and how you could be involved. Also, your participation is **entirely voluntary** and you are free to decline to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part.

This study has been approved by the **Health Research Ethics Committee of the Faculty of Health Sciences of the North-West University (NWU-00201-14-A1)** and will be conducted according to the ethical guidelines and principles of the international Declaration of Helsinki and the ethical guidelines of the National Health Research Ethics Council. It might be necessary for the research ethics committee members or relevant authorities to inspect the research records.

What is this research study all about?

- *This study will be conducted at the Potchefstroom Campus of the North-West University and will involve blood sampling, heart rate and physical activity monitoring, physical and motor performance tests, the completion of psychological questionnaires as well as a seven-day weighed food record for analyses during several time periods before and after recovery interventions. Experienced sport science researchers trained in human movement, sport science and nutrition will conduct the analyses and tests. Thirty participants will be included in this study.*
- *The objectives of this research are to determine the effects of various recovery techniques (cold water immersion (CWI), contrast water therapy (CWT), self-myofascial release and breathing techniques (SMRDB) and passive recovery (PAR)) on the lower and upper body explosive power output, forearm strength, several haematological analytes, HRV (heart rate variability), as well as certain psychological parameters in a cohort of university-level rugby players. The researchers also want to determine If there are any statistically significant relationships between several indicators of recovery (upper body explosive power output, forearm strength, several haematological analytes, HRV as well as certain psychological parameters) in a cohort of university-level rugby players.*

Furthermore, another aim is to determine the effect of dietary intake on the HRV in a cohort of university-level rugby players. Moreover, the researchers want to determine the normal dietary practices, supplement use and nutritional knowledge of a cohort of university-level rugby players. The last aim is to determine the significant acute changes in certain haematological, physical, motor performance and psychological parameters after execution of a 15 minute anaerobic rugby specific session in a cohort of university-level rugby players.

Why have you been invited to participate?

- *You have been invited to participate because you are a male u/21 rugby player from the Potchefstroom Campus of the North-West University.*
- *You have also complied with the following inclusion criteria: You are actively involved and training as a member of the Rugby Institute and are totally injury and illness free at the time of testing. Your manager and coach, and you, yourself provided voluntary consent to participate in the study. In the event that you want to participate in the study but the coach or manager do not want to give permission to you to participate, your wish will be fulfilled.*
- *Moreover, you will only be included in the study if are prepared to attend the familiarization session, do all the motor and physical performance tests, as well as undergo blood sampling during the duration of each of the testing occasions.*
- *Furthermore, you will only be included if you are willing to undergo the different recovery interventions.*
- *Lastly, you will also only be included in the study if you did not participate in strenuous physical activity that may influence the physical or physiological responses of the body for at least 48 hours before the scheduled tests.*
- *You will be excluded if: you do adhere to the above-mentioned inclusion criteria or if you become injured or ill at any time during the testing period or if you voluntary withdraw from the study at any time.*

What will your responsibilities be?

- *You will be expected to undergo anthropometric measurements (body mass and stature), provide blood (at least 6 finger pricks x 3 for each week of testing) for blood analyses,*

complete several questionnaires and a seven-day weighed food record, execute several physical and motor performance tests: the Vertical Jump Test, the Five Repetition Smith Machine Bench Throw Test and the Grip Strength test, perform an anaerobic shuttle run session as well as various recovery techniques. These tests will be performed seven times during an one week period and will be repeated twice over another two weeks. All together all the analyses and tests will take more or less 60 minutes to perform. You will also be expected to wear a Global Positioning System and heart rate monitor during execution of the anaerobic session as well as an Actiheart monitor for 48 hours each week.

Will you benefit from taking part in this research?

- *Among the direct benefits are that you will be able to gain access to your results. Their data will also be used to explain to you and/or your sport scientist orally which recovery techniques are more effective in causing acute physical, physiological and psychological recovery for yourself. You and your sport scientists will also be afforded the opportunity to talk to the researchers about any recovery advice that you may have a need for. Furthermore, HRV data will allow the researchers to evaluate your day to day recovery levels which can assist your coach and yourself to identify weak points and enable you to identify factors that are detrimental to your recovery. As part of the research project you will also be afforded the opportunity to obtain information with regard to your dietary preferences and profile as well as recommendations to improve your diet. Data with regard to mood states, sleeping quality and quantity will also allow researchers to provide you with feedback concerning these aspects.*
- *An indirect benefit of the study is an expansion of existing expert knowledge in the field of Applied Sport Science which can be transferred to the wider sporting community.*

Are there risks involved in your taking part in this research?

- *Risks will be minimised and the researchers will aim to maximise potential benefits that are likely to have a valuable impact on you either directly or indirectly. An experienced sport scientist will perform a warm before the battery of physical and motor performance tests to prepare you physically and physiologically for the test demands and to decrease injury risk. A medical doctor will be on standby during the total duration of the project,*

should any injuries occur. In case of illness or injury you will immediately be withdrawn from the project and will be allowed to leave at any time if they feel so.

- *The risk for infection during blood sampling will be minimized by employing the following procedures: Before the finger prick method is employed the fingertip will be cleansed thoroughly by making use of a Webcol, alcohol swap and dried by a sterile gauze pad. The researchers who collect the blood samples will wear powder-free, sterile surgical gloves at all times during blood sampling. Gloves will be replaced each time that another player's blood samples are taken. A sterile, single-use lancing device will be used to swiftly puncture the finger slightly lateral to the ball of the finger. After blood sampling the fingertip will again be cleansed by using a Webcol swap and dried by a sterile gauze pad. A sterile cotton ball will then be placed on the punctured area and closed with a hypoallergenic Band-aid adhesive bandage to stop any bleeding. All used materials (lancets, blood lactate strips, Webcols swaps, gauze pads, surgical gloves, etc.) will immediately be discarded into appropriate medical waste containers so as to minimize the risk for contact with contaminated blood. You may experience a bit of discomfort due to the frequency of the finger prick technique (at least 6 finger pricks for each week of testing) that is used to collect venous blood. You will however be familiarized with this technique during the familiarization day a week before the project starts.*
- *Players, especially the back line players, may find the CWI uncomfortable due to the temperature of the water ($8 \pm 1^{\circ}\text{C}$) and the duration of immersion (20 minutes). Although there is always a risk that you may experience "cold shock" due to the sudden immersion in cold water, the fact that you are familiar with this recovery technique due to the fact that you are subjected to it frequently during training sessions, will decrease the risk of "cold shock".*
- *You may also experience extreme fatigue, muscle discomfort and nausea due to execution of the anaerobic session. A scientifically compiled warm-up will however be performed before execution of the anaerobic session to minimize injury risk and to prepare the body for this session. Furthermore, you will be familiarised with the test during the familiarization session. You are however familiar with these type of interval sessions due to the fact that you regularly perform it during training.*

What will happen in the unlikely event of some form of discomfort occurring as a direct result of your taking part in this research study?

- *Should you have the need for further discussions after the execution of the tests or analyses of matches an opportunity will be arranged for you to do so. In case of illness or injury you will immediately be withdrawn from the study and will be allowed to leave at any time if you feel so. During the execution of the physical tests a medical physician will be on standby should any medical attention be needed.*

Who will have access to the data?

- *Anonymity will be partial due to the fact that the sport scientist wants feedback with regard to the outcome of the different recovery techniques but the researchers will respect the decision of each player in order to protect his anonymity. Data will be coded to ensure that no link can be made to a specific player. Reporting of findings will be anonymous by only authorising the head researcher to have control over the distribution of these findings. Only the head researcher and research assistants will have access to the data and will also sign a confidentiality agreement to protect players. Data will be kept safe and secure by locking hard copies in locked cupboards in the researcher's office and for electronic data it will be password protected. Data will be stored for 7 years.*

Will you be paid to take part in this study and are there any costs involved?

No, you will not be paid to take part in the study. There will also be no costs involved for you, if you do take part.

Is there anything else that you should know or do?

- You can contact **Prof Ben Coetzee** at **018 299 1803**; **ben.coetzee@nwu.ac.za** if you have any further queries or encounter any problems.
- You can contact the Health Research Ethics Committee via Mrs Carolien van Zyl at 018 299 2094; **carolien.vanzyl@nwu.ac.za** if you have any concerns or complaints that have not been adequately addressed by the researcher.
- You will receive a copy of this information and consent form for your own records.

How will you know about the findings?

- The findings of the research will be shared with you if you are interested. The main findings of the project will be shared with the head sport scientist of the Rugby Institute (Jacus Coetzee) so that it can be used to your benefit. The researchers will try and share the information three months after conclusion of the project orally with the last-mentioned person. You are welcome to contact us regarding the findings of the research. We will be sharing the findings with you as soon as it is available.

Declaration by participant

By signing below, I **agree to take part in a research study entitled:** Effects of different recovery techniques on certain physical, motor performance, psychological and haematological components in university-level rugby players.

I declare that:

- I have read this information and consent form and it is written in a language with which I am fluent and comfortable.
- I have had a chance to ask questions to both the person obtaining consent, as well as the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the study before it has finished, if the researcher feels it is in my best interests, or if I do not follow the study plan, as agreed to.

Signed at (*place*) on (*date*) 20....

.....

Signature of participant

.....

Signature of witness

Declaration by person obtaining consent

I (*name*) declare that:

- I explained the information in this document to
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) on (*date*) 20....

.....

Signature of person obtaining consent

.....

Signature of witness

Declaration by researcher

I (*name*) declare that:

- I explained the information in this document to
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I did/did not use an interpreter.

Signed at (*place*) on (*date*) 20....

.....

Signature of researcher

.....

Signature of witness

Appendix B: Raw data card



RAW DATA FOR RUGBY RECOVERY PROJECT – NAME OF PLAYER AND NUMBER: _____

Recovery group: CWI or PAR (encircle the relevant option)

BASE LINE TEST (TUESDAY MORNING)	
TEST COMPONENT	1 ST TIME
4. BODY MASS (KG)	
5. BODY STATURE (CM)	
6. LACTATE	

Recovery indicators (Name and Surname: _____)

Please insert the following data that relates to the time period before this testing session:

1. How many hours did you sleep during the previous night?

2 hours	3 hours	4 hours	5 hours	6 hours	7 hours	8 hours	9 hours	10 hours
---------	---------	---------	---------	---------	---------	---------	---------	----------

2. Rate the quality of sleep of the previous night:

Very poor	Poor	Average	Good	Very good
-----------	------	---------	------	-----------

3. What was the shade of your urine the last time that you went to the toilet?

Transparant	A shade of light yellow	Light yellow	Yellow	Dark Yellow	Very dark yellow



NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT
POTCHEFSTROOM CAMPUS

**RAW DATA FOR RUGBY RECOVERY PROJECT – NAME OF PLAYER AND
NUMBER: _____**

Recovery group: CWT or PAR (encircle the relevant option)

BASE LINE TEST (TUESDAY MORNING)	
TEST COMPONENT	1ST TIME
7. BODY MASS (KG)	
8. BODY STATURE (CM)	
9. LACTATE	

Recovery indicators (Name and Surname: _____)

Please insert the following data that relates to the time period before this testing session:

1. How many hours did you sleep during the previous night?

2 hours	3 hours	4 hours	5 hours	6 hours	7 hours	8 hours	9 hours	10 hours
---------	---------	---------	---------	---------	---------	---------	---------	----------

2. Rate the quality of sleep of the previous night:

Very poor	Poor	Average	Good	Very good
-----------	------	---------	------	-----------

3. What was the shade of your urine the last time that you went to the toilet?

Transparant	A shade of light yellow	Light yellow	Yellow	Dark Yellow	Very dark yellow

Appendix C: Questionnaire:

Demographic and general information



General Demographic and Information Questionnaire for the Rugby Recovery Project

GENERAL INFORMATION

Please write clearly!

1. GEOGRAPHICAL INFORMATION

1.1 Surname:

Initials

First Name

--	--	--

1.2 Age:

<u>Years:</u>	<u>Months:</u>
---------------	----------------

1.3 Birth date:

<u>Year:</u>	<u>Month:</u>	<u>Day:</u>
--------------	---------------	-------------

1.4 Permanent residential address in South Africa:

1.5 Permanent postal address in South Africa:

1.6 Phone numbers:

<u>Home:</u>	<u>Work:</u>
<u>Fax:</u>	<u>Cell:</u>
<u>E-mail:</u>	

1.7 Ethnic group

White	Coloured	Black	Indian
-------	----------	-------	--------

In the next few question cross out the answers that are applicable to you!!

2. INFORMATION REGARDING TRAINING HABITS**2.1 Years you've been playing rugby - since you started to specialise in rugby.**

1-2 years	3-4 years	5-6 years	7-8 years	8-9 years	10-11 years	12 or more
-----------	-----------	-----------	-----------	-----------	-------------	------------

2.2 Frequency of training - how many days per week do you normally train?

1 day	2 days	3 days	4 days	5 days	6 days	7 days
-------	--------	--------	--------	--------	--------	--------

2.3 Frequency of training - how many days per week do you normally do weight training?

1 day	2 days	3 days	4 days	5 days	6 days	7 days
-------	--------	--------	--------	--------	--------	--------

2.4 Frequency of training - how many days per week do you normally have field sessions?

1 day	2 days	3 days	4 days	5 days	6 days	7 days
-------	--------	--------	--------	--------	--------	--------

2.5 How many hours per day do you normally train?

1 hour	2 hours	3 hours	4 hours	5 hours	6 hours	7 or more
--------	---------	---------	---------	---------	---------	-----------

2.6 How many hours per day do you normally spend on weight training?

1 hour	2 hours	3 hours	4 hours	5 hours	6 hours	7 or more
--------	---------	---------	---------	---------	---------	-----------

2.7 How many hours per day do you normally spend on training on the field?

1 hour	2 hours	3 hours	4 hours	5 hours	6 hours	7 or more
--------	---------	---------	---------	---------	---------	-----------

2.8 Do you spend any time on psychological preparation for rugby and competitions?

Never	*Sometimes	*Often	*Always
-------	------------	--------	---------

*** Please specify the type of psychological preparation you do if you marked any of these three options:**

3. MEDICAL INFORMATION

3.1 Please describe any past or current musculoskeletal conditions you have incurred (i.e., muscle pulls, sprains, fractures, surgery, back pain, or any general discomfort):

Head/Neck:

Shoulder/Clavicle:

Arm/Elbow/Wrist/Hand:

Back:

Hip/Pelvis:

Thigh/Knee:

Lower leg/Ankle/Foot:

3.2 Please list any medication being taken currently and/or taken during the last year:

3.3 List any other illness or disorder that a physician has told you of:

4. COMPETITION DATA

4.1 At what level are you competing this year?

4.2 What is the highest level that you competed at last year?

Club:	Provincial:	National:	International:
-------	-------------	-----------	----------------

4.3 How many matches, approximately, have you played?

Club:	Provincial/National:
-------	----------------------

4.4 What were the highest achievements you attained the past two years?

Achievement	Competition	Date

4.5 What position/s do you usually play during matches?

1.
2.
3.

Appendix D: Questionnaire: The Recovery-Stress Questionnaire (RESTQ-Sport)

RESTQ-52 SPORT

NAME & SURNAME: _____

This questionnaire consists of a series of statements. These statements possibly describe your psychic or physical well-being or your activities during the past few days and nights.

Please select the answer that most accurately reflects your thoughts and activities. Indicate how often each statement was right in your case in the past days.

The statements related to performance should refer to performance during competition as well as during practice.

Please do not leave any statement blank.

Example:

In the past 3 days/nights

...I read the newspaper

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

In this example, the number 5 is marked. This means that you read a newspaper very often in the past three days.

In the past 3 days/nights...

1) ... I watched TV

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

2) ... *I laughed*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

3) ... *I was in a bad mood*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

4) ... *I felt physically relaxed*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

In the past 3 days/nights ...

5) ... *I was in good spirits*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

6) ... *I had difficulties in concentrating*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

7) ... *I worried about unresolved problems*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

8) ... *I had a good time with my friends*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

9) ... *I had a headache*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

10) ... *I was dead tired after work/class*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

11) ... *I was successful in what I did*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

12) ... *I felt uncomfortable*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

13) ... *I was annoyed by others*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

14) ... *I felt down*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

In the past 3 days/nights...

15) ... *I had a satisfying sleep*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

16) ... *I was fed up with everything*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

17) ... *I was in a good mood*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

18) ... *I was overtired*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

19) ... *I slept restlessly*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

20) ... *I was annoyed*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

21) ... *I felt as if I could get everything done*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

22) ... *I was upset*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

23) ... *I put off making decisions*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

24) ... *I made important decisions*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

In the past 3 days/nights ...

25) ... *I felt under pressure*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More	Very often	Always

often						
26) ... <i>parts of my body were aching</i>						
0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always
often						
27) ... <i>I could not get rest during the breaks</i>						
0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always
often						
28) ... <i>I was convinced I could achieve my set goals during performance</i>						
0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always
often						
29) ... <i>I recovered well physically</i>						
0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always
often						
30) ... <i>I felt burned out by my sport</i>						
0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always
often						
31) ... <i>I accomplished many worthwhile things in my sport</i>						
0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always
often						
32) ... <i>I prepared myself mentally for performance</i>						
0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always
often						

33) ... my muscles felt stiff or tense during performance

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

34) ... I had the impression there were too few breaks

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

In the past 3 days/nights ...

35) ... I was convinced that I could achieve my performance at any time

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

36) ... I dealt very effectively with my teammates' problems

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

37) ... I was in a good condition physically

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

38) ... I pushed myself during performance

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

39) ... I felt emotionally drained from performance

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

40) ... *I had muscle pain after performance*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

41) ... *I was convinced that I performed well*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

42) ... *too much was demanded of me during the breaks*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

43) ... *I psyched myself up before performance*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

44) ... *I felt that I wanted to quit my sport*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

In the past 3 days/nights ...

45) ... *I felt very energetic*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

46) ... *I easily understood how my teammates felt about things*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

47) ... *I was convinced that I had trained well*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

48) ... *the breaks were not at the right times*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

49) ... *I felt vulnerable to injuries*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

50) ... *I set definite goals for myself during performance*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

51) ... *my body felt strong*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

52) ... *I felt frustrated by my sport*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

53) ... *I dealt with emotional problems in my sport very calmly*

0	1	2	3	4	5	6
Never	Seldom	Sometimes	Often	More often	Very often	Always

END

Appendix E: Guidelines for authors:

International Journal of Sport and Exercise Psychology

Instructions to authors

International Journal of Sport and Exercise Psychology use ScholarOne Manuscripts (previously Manuscript Central) to peer review manuscript submissions. Complete guidelines for preparing and submitting your manuscript to this journal are provided below.

International Journal of Sport and Exercise Psychology consider all manuscripts on the strict condition that:

- a) The manuscript is your own original work, and does not duplicate any other previously published work, including your own previously published work.
- b) The manuscript has been submitted only to *International Journal of Sport and Exercise Psychology*; it is not under consideration or peer review or accepted for publication or in press or published elsewhere.
- c) The manuscript contains nothing that is abusive, defamatory, libellous, obscene, fraudulent, or illegal.

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Manuscript preparation

General guidelines

- d) Manuscripts are accepted in English. British English spelling and punctuation are preferred. Please use double quotation marks, except where “a quotation is ‘within’ a quotation”. Long quotations of 40 words or more should be indented without quotation marks.
- e) A typical manuscript will not exceed 7500 words including tables, references, captions, footnotes and endnotes. Manuscripts that greatly exceed this will be critically reviewed with respect to length. Authors should include a word count with their manuscript.
- f) Manuscripts should be compiled in the following order: title page; abstract; keywords; main text; acknowledgements; references; appendices (as appropriate); table(s) with caption(s) (on individual pages); figure caption(s) (as a list).
- g) Abstracts of 250 words are required for all manuscripts submitted.
- h) Each manuscript should have 3 to 5 keywords.
- i) Search engine optimization (SEO) is a means of making your article more visible to anyone who might be looking for it.
- j) Section headings should be concise.
- k) All authors of a manuscript should include their full names, affiliations, postal addresses, telephone numbers and email addresses on the cover page of the manuscript. One author should be identified as the corresponding author. Please give the affiliation where the research was conducted. If any of the named co-authors moves affiliation during the peer review process, the new affiliation can be given as a footnote. Please note that no changes to affiliation can be made after the manuscript is accepted. Please note that the email address of the corresponding author will normally be displayed in the article PDF (depending on the journal style) and the online article.
- l) All persons who have a reasonable claim to authorship must be named in the manuscript as co-authors; the corresponding author must be authorized by all co-authors to act as an agent on their behalf in all matters pertaining to publication of the manuscript, and the order of names should be agreed by all authors.
- m) Biographical notes on contributors are not required for this journal.
- n) Please supply all details required by any funding and grant-awarding bodies as an Acknowledgement on the title page of the manuscript, in a separate paragraph, as follows:
 - *For single agency grants:* "This work was supported by the [Funding Agency] under Grant [number xxxx]."

- *For multiple agency grants:* "This work was supported by the [Funding Agency 1] under Grant [number xxxx]; [Funding Agency 2] under Grant [number xxxx]; and [Funding Agency 3] under Grant [number xxxx]."
- o) Authors must also incorporate a Disclosure Statement which will acknowledge any financial interest or benefit they have arising from the direct applications of their research.
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- q) Authors must adhere to SI units. Units are not italicized.
- r) When using a word which is or is asserted to be a proprietary term or trade mark, authors must use the symbol ® or TM.

Style guidelines

Advice to authors on preparing a manuscript:

- s) Please follow any specific instructions for authors provided by the Editor of the journal
- t) Font: Times New Roman, 12 point. Use margins of at least 2.5 cm (1 inch). Further details of how to insert special characters, accents and diacritics are available [here](#).
- u) Title: Use bold for your article title, with an initial capital letter for any proper nouns.
- v) Authors' names: Give the names of all contributing authors on the title page exactly as you wish them to appear in the published article.
- w) Affiliations: List the affiliation of each author (department, university, city, country).
- x) Correspondence details: Please provide an institutional email address for the corresponding author. Full postal details are also needed by the publisher, but will not necessarily be published.
- y) Anonymity for peer review: Ensure your identity and that of your co-authors is not revealed in the text of your article or in your manuscript files when submitting the manuscript for review.
- z) Abstract: Indicate the abstract paragraph with a heading or by reducing the font size.
- aa) Keywords: Please provide five or six keywords to help readers find your article. Advice on selecting suitable keywords is available [here](#).
- bb) Headings: Please indicate the level of the section headings in your article:
 - First-level headings (e.g. Introduction, Conclusion) should be in bold, with an initial capital letter for any proper nouns.

- ☐ Second-level headings should be in bold italics, with an initial capital letter for any proper nouns.
- ☐ Third-level headings should be in italics, with an initial capital letter for any proper nouns.
- ☐ Fourth-level headings should also be in italics, at the beginning of a paragraph. The text follows immediately after a full stop (full point) or other punctuation mark.

Tables and figures: Indicate in the text where the tables and figures should appear, for example by inserting [Table 1 near here]. The actual tables and figures should be supplied either at the end of the text or in a separate file as requested by the Editor. Ensure you have permission to use any figures you are reproducing from another source. Advice on artwork is available [here](#). Advice on tables is available [here](#).

- cc) Running heads and received dates are not required when submitting a manuscript for review.
- dd) If your article is accepted for publication, it will be copy-edited and typeset in the correct style for the journal.
- ee) Word templates are available for this journal. If you are not able to use the template via the links or if you have any other template queries, please contact authortemplate@tandf.co.uk.

Description of the Journal's reference style

International Journal of Sport and Exercise Psychology use APA (American Psychological Association) reference style. APA references are widely used in the social sciences, education, engineering and business. For detailed information, please see the *Publication Manual of the American Psychological Association*, 6th edition, <http://www.apastyle.org/> and <http://blog.apastyle.org/>.

Guide to using mathematical scripts and equations

- ff) Special care should be taken with mathematical scripts, especially subscripts and superscripts and differentiation between the letter “ell” and the figure one, and the letter “oh” and the figure zero. If your keyboard or PC does not have the characters you need, or when using longhand, it is important to differentiate between: K and k; X, x and × (multiplication); asterisks intended to appear when published as multiplication signs and those intended to remain as asterisks; etc. Special symbols, and others used to stand for symbols not available in the character set of your PC, should be highlighted in the text and explained in the margin.

In some cases it is helpful to supply annotated lists of symbols for the guidance of the sub-editor and the typesetter, and/or a “Nomenclature” section preceding the “Introduction”.

- gg) In both displayed equations and in text, scalar variables must be in italics, with non-variable matter in upright type.
- hh) For simple fractions in the text, the solidus “/” should be used instead of a horizontal line, care being taken to insert parentheses where necessary to avoid ambiguity. Exceptions are the proper fractions available as single type on keyboards and in character sets (e.g. $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$).
- ii) The solidus is not generally used for units: m s⁻¹ not m/s, but note electrons/s, counts/channel, etc.
- jj) Displayed equations referred to in the text should be numbered serially ((1), (2), etc.) on the right-hand side of the page. Short expressions not referred to by any number will usually be incorporated in the text.
- kk) Symbols used to represent tensors, matrices, vectors and scalar variables should either be used as required from the character set of the application you are using or marked on hard-copy by underlining with a wavy underline for bold, a straight underline for italic and a straight red underline for sans serif.
- ll) The following styles are preferred: upright bold sans serif **r** for tensors, bold serif italic ***r*** for vectors, upright bold serif **r** for matrices, and mediumface sloping serif *r* for scalar variables. In mathematical expressions, the use of “d” for differential should be made clear and coded in roman, not italic.
- mm) Typographical requirements must be clearly indicated at their first occurrence, e.g. Greek, Roman, script, sans serif, bold, italic. Authors will be charged for corrections at proof stage resulting from a failure to do so.
- nn) Braces, brackets and parentheses are used in the order { [()] }, except where mathematical convention dictates otherwise (e.g. square brackets for commutators and anticommutators; braces for the exponent in exponentials).
- oo) For units and symbols, the SI system should be used. Where measurements are given in other systems, conversion factors or conversions should be inserted by the author.
- pp) Mathematical equations should preferably be typewritten, with subscripts and superscripts clearly shown. It is helpful to identify unusual or ambiguous symbols in the margin when they first occur. Please ensure all symbols are described in the text. If equations are numbered, consecutive Arabic numbers in parentheses should be used. Equations may be referred to in the text as “equation (1)”, “equations (2)–(4)”. To simplify typesetting, please

use: (1) the “exp” form of complex exponential functions; (2) fractional exponents instead of root signs; and (3) the solidus (/) to simplify fractions e.g. 3/4, $\exp x^{1/2}$. Other letters not marked will be set in roman type. Please supply reproducible artwork for equations containing ring formulae and other complex chemical structures. Schemes should also be numbered with consecutive Arabic numbers

Figures

- Please provide the highest quality figure format possible. Please be sure that all imported scanned material is scanned at the appropriate resolution: 1200 dpi for line art, 600 dpi for grayscale and 300 dpi for colour.
- Figures must be saved separate to text. Please do not embed figures in the manuscript file.
- Files should be saved as one of the following formats: TIFF (tagged image file format), PostScript or EPS (encapsulated PostScript), and should contain all the necessary font information and the source file of the application (e.g. CorelDraw/Mac, CorelDraw/PC).
- All figures must be numbered in the order in which they appear in the manuscript (e.g. Figure 1, Figure 2). In multi-part figures, each part should be labelled (e.g. Figure 1(a), Figure 1(b)).
- Figure captions must be saved separately, as part of the file containing the complete text of the manuscript, and numbered correspondingly.
- The filename for a graphic should be descriptive of the graphic, e.g. Figure1, Figure2a.

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Appendix F: Guidelines for authors:

Journal of Applied Sport Psychology

Instructions to authors

This journal uses ScholarOne Manuscripts (previously Manuscript Central) to peer review manuscript submissions. Complete guidelines for preparing and submitting your manuscript to this journal are provided below.

The *Journal of Applied Sport Psychology* uses CrossCheck™ software to screen papers for unoriginal material. By submitting your paper to the *Journal of Applied Sport Psychology* you are agreeing to any necessary originality checks your paper may have to undergo during the peer review and production processes.

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The *Journal of Applied Sport Psychology* is a nonproprietary journal that is operated by the Association for Applied Sport Psychology for the promotion of quality research in the field of applied sport psychology. The publisher of the *JASP* is Taylor and Francis, Inc. of Philadelphia, PA. The *JASP* is published four times a year, and is a refereed publication with all submissions reviewed by three peers via blind review process. The editor of the journal is selected by the Executive Board of AASP by a formal vote. He/She is appointed to a three-year term with one consecutive renewal possible if so voted by the Executive Board. The Associate Editors are approved by the Executive Board of the Association and serve staggered terms ranging from three to five years. An individual holding an AASP Executive Board office as a Division Head cannot serve as an Associate Editor. Editorial Board members are appointed to three, four or five-year terms as determined by the Editorial staff of the *JASP*. Editorial Board members may be reappointed to one consecutive term or may be asked to retire their seat on the Board at the discretion of the Editorial staff. The journal is a direct benefit of membership in AASP and is received by student and professional members.

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All parts of the manuscript should be typewritten, double-spaced, with margins of at least one inch on all sides. Articles will normally be no more than 30 double-spaced pages in length (including tables, figures and references). Articles should also include a title page, a 100-word abstract and complete references. The title of the manuscript should reappear on the first page of the text. Authors should also supply a shortened version of the title suitable for the running head, not exceeding 50 character spaces. Research notes (13 pages including references, tables, figures, 100-word abstract) are welcomed submissions. Manuscripts, including tables, figures and references, should be prepared in accordance with the Publication Manual of the American Psychology Association (Sixth Edition, 2010). Copies of the manual can be obtained from the Publication Department, American Psychological Association, 750 First Street NE, Washington, DC 20002-4242; phone (202) 336-5500.

Authors are to avoid the use of sexist, racist and otherwise offensive language. Manuscript copies should be clear and legible and all figures must be camera ready. All reviews are blind and conducted by two reviewers and Associate Editors with the review process taking 8–10 weeks. Authors will receive typed feedback regarding the editorial decisions made on their manuscript and any suggested revision recommendations. Authors should be prepared to provide their raw data if requested during the review process. A file copy of the manuscript should be kept by the author.

Illustrations

Illustrations submitted (line drawings, halftones, photos, photomicrographs, etc.) should be clean originals or digital files. Digital files are recommended for highest quality reproduction and should follow these guidelines:

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A short descriptive title should appear above each table with a clear legend and any footnotes suitably identified below. All units must be included. Figures should be completely labeled, taking into account necessary size reduction. Captions should be typed, double-spaced, on a separate sheet.

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Search Engine Optimization

Search Engine Optimization (SEO) is a means of making your article more visible to anyone who might be looking for it.

Appendix G: Proof of language editing

Declaration

This is to declare that I,

Maria E Nelson,

accredited language practitioner of the

South African Translators' Institute

have language edited the

dissertation by

N. Tinkler

21619476

with the title

The effects of different post-exercise recovery techniques on the subscales of the Recovery-Stress Questionnaire in university-level rugby players

Dr. Maria E Nelson
Accredited Language Practitioner,
South African Translators' Institute
Membership no. 1000036
Date: 25 November 2015