

*The relationship
between exercise,
amenorrhoea,
percentage body fat
and disordered eating
among adolescent
female runners*

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*The relationship between exercise,
amenorrhoea, percentage body fat and
disordered eating among adolescent
female runners*

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(B.A. Hons.)*



*Dissertation submitted in partial fulfillment of the
requirements for the degree Magister Artium in the
faculty of Health Sciences at the Potchefstroom campus
of the North-West University.*

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<i>Assistant supervisor:</i>	<i>Dr H.H Wright</i>

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Foreword

- *God, give us the grace to accept with serenity the things that cannot be changed,
courage to change the things that should be changed, and the wisdom to
distinguish between them -*
- *Prayer of St Francis*

Without the guidance, grace and mercy of my Heavenly Father, the completion of this study would not have been possible. I am truly grateful for all of the talents and opportunities He has blessed me with and I pray that He will grant me the wisdom and strength to always keep my eyes fixed on Him.

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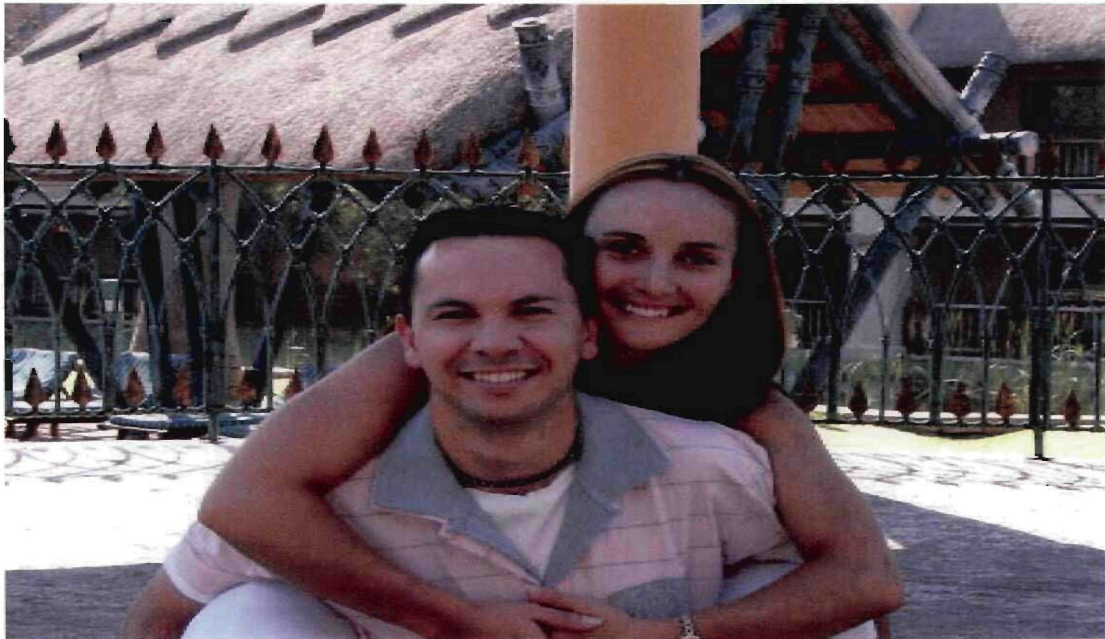
The author

May 2008

Dedicated to my parents



And my Love



Declaration

The co-authors of the articles that form part of this dissertation, Prof. J. Hans de Ridder (supervisor), Prof. Dawie D.J. Malan (co-supervisor) and Dr. Hattie Wright (assistant supervisor), hereby give permission to the candidate, Ms Tershia Botha, to include the two articles as part of a Masters dissertation. The contribution (advisory and supportive) of these co-authors was kept within reasonable limits, thereby enabling the candidate to submit this dissertation for examination purpose. This dissertation, therefore, serves as partial fulfilment of the requirements for the M.A. degree within the School of Biokinetics, Recreation and Sports Science in the Faculty of Health Sciences at the North-West University, Potchefstroom Campus.

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Summary

The American College of Sports Medicine first described the Female Athlete Triad a decade ago (ACSM, 1997:5). It is a life-threatening syndrome that is defined by disordered eating, amenorrhoea and osteoporosis (Thompson, 2007:129). Although physical exercise has many benefits, too much exercise can negatively affect the female athlete, causing amenorrhoea. When athletes restrict food intake and train hard, hormonal changes can affect the reproductive system and cause menstrual dysfunction. The first purpose of this study was therefore to determine if there is a relationship between body composition, disordered eating and menstrual dysfunction among a group of 14 – 25 year-old South African female athletes. The second purpose of this study was to determine if there is a relationship between training volume and menstrual dysfunction among a group of 14 – 25 year-old South African female athletes.

Menstrual dysfunction was determined by a self-administered questionnaire and the incidence of disordered eating by the EAT-26 and the EDI questionnaires. Body composition was calculated by using the BOD POD. Menstrual dysfunction and training volume were determined by a self-administered questionnaire and by using the Exercise Dependence Questionnaire. Non-parametric statistics were obtained due to the small sample size and since subjects were recruited on the basis of availability. Descriptive statistics (mean $\pm$ SD) of all variables for the total group of female athletes were obtained and the three different groups were compared, using ANOVA and two-way frequency tables. Practically significant differences were determined.

At the time of the survey, 6 athletes had not yet reached menarche, while two of the athletes only reached menarche at the age of 17 years. Practically significant differences were found between the inter-high athletes' age of menarche and the provincial and national athletes' age of menarche. However, no practically significant differences were

found between the three groups in terms of menstrual regularity. No practically significant differences were found between the three groups in terms of height, weight, BMI and fat-free mass. The inter-high group had a practically significant higher percentage body fat than the provincial group. No practically significant differences were found between the three groups of athletes for all the subscales of the EDI, with the exception of the perfectionism subscale. The national athletes had a practically significant higher score than both the inter-high and provincial athletes. No practically significant differences were found between the three groups of athletes regarding the EAT-26 as well as the three groups of athletes regarding their training sessions per week, frequency of training sessions per day or the duration of their training sessions. However, 30, 43% reported a change in their menstrual cycle during the training season and 23, 91% reported a change in their menstrual cycle during the season and with an increase in their training volume.

The total group of athletes was also redivided into groups according to their menstrual dysfunction to evaluate the influence of training volume on amenorrhoea. However, no practically significant differences were found between these three groups of athletes and their training sessions per week, frequency of training sessions per day or the duration of their training sessions.

It can therefore be concluded that no relationship was found between body composition, disordered eating and menstrual dysfunction or between training volume and menstrual dysfunction among these groups of 14 – 25 year old South African female athletes.

Key words: Female triad, amenorrhoea, eating disorders, adolescents, athletes, endurance athletes, exercise, BMI, training volume, body composition, osteoporosis, anthropometry, BOD POD, menarche.

Opsomming

Die “American College of Sports Medicine” het ‘n dekade gelede vir die eerste keer die Vroulike Atleet-triade (Female Athlete Triad) beskryf (ACSM, 1997:5). Dit is ‘n lewensbedreigende sindroom wat onderskei word deur versteurde eetpatrone, amenorree en osteoporose (Thompson, 2007:129). Hoewel fisieke oefening verskeie voordele inhou, kan te veel oefening die vroulike atleet negatief beïnvloed en amenorree veroorsaak. Wanneer altlete voedselinname beperk en hard oefen, kan hormonale veranderinge die reproduksiestelsel aantas en menstruele disfunksie veroorsaak. Die eerste doelwit van hierdie studie was dus om vas te stel of daar ‘n verband bestaan tussen liggaamsamestelling, versteurde eetpatrone en menstruele disfunksie binne ‘n groep 14 – 25-jarige Suid-Afrikaanse vroulike atlete. Die tweede doelwit van die studie was om vas te stel of daar ‘n verwantskap bestaan tussen oefenvolume en menstruele disfunksie binne ‘n groep van 14 – 25-jarige Suid-Afrikaanse vroulike atlete.

Menstruele disfunksie is vasgestel deur ‘n selfgeadministreerde vraelys en versteurde eetpatrone deur die EAT-26 en die EDI-vraelyste. Liggaamsamestelling is bereken deur die BOD POD te gebruik. Menstruele disfunksie en oefenvolume is vasgestel deur ‘n selfgeadministreerde vraelys en deur die Oefeningafhanklikheidsvraelys (Exercise Dependence Questionnaire). Nie-parametriese statistieke is bekom vanweë die klein proefgrootte en omdat die proefpersone gekies is op grond van hul beskikbaarheid. Beskrywende statistieke (gemiddeld $\pm$ SD) van al die veranderlikes is bekom en die drie groepe is vergelyk deur gebruik te maak van ANOVA- en tweerigting frekwensietabelle. Prakties beduidende verskille is vasgestel.

Tydens die opname het 6 atlete nog nie menarg bereik nie, terwyl twee van die atlete eers op die ouderdom van 17 jaar menarg bereik het. Prakties betekenisvolle verskille is gevind tussen die interhoëratlete en die provinsiale en nasionale atlete se ouderdom van

menarg. Geen prakties betekenisvolle verskille is egter gevind tussen die groepe wat betref gereeldheid van menstruasie nie. Geen prakties betekenisvolle verskille is gevind tussen die groepe betreffende hoogte, gewig, LMI en vetvry massa nie. Die interhoërgroep het 'n prakties betekenisvolle hoër persentasie liggaamsvet gehad as die provinsiale groep. Geen prakties betekenisvolle verskille is gevind tussen die drie groepe atlete vir al die subskale van die EDI nie, behalwe vir die subskaal oor perfeksionisme. Die nasionale atlete het prakties betekenisvoller hoër tellings behaal as beide die interhoër- en provinsiale atlete. Geen prakties betekenisvolle verskille is gevind tussen die drie groepe atlete wat betref die EAT-26 sowel as atlete se oefensessies per week, frekwensie van oefening per dag of die duur van hul oefensessies nie. Dertig (30) of 43% het 'n verandering in hul menstruele siklus aangemeld gedurende die oefenseisoen en 23 of 91% het 'n verandering in hul menstruele siklus gedurende die seisoen en met verhoogde oefenvolumes aangemeld.

Die totale groep atlete is weer ingedeel in groepe volgens hul menstruele disfunksie om die oefenvolume se uitwerking op amenorree vas te stel. Geen prakties betekenisvolle verskille is egter gevind tussen die drie groepe atlete en hul oefensessies per week, frekwensie van oefensessies per dag of die duur van hul oefensessies nie.

Daar kan dus afgelei word dat geen verwantskap gevind is tussen liggaamsamestelling, versteurde eetgewoontes en menstruele disfunksie of tussen oefenvolume en menstruele disfunksie tussen hierdie groepe van 14 – 25-jarige Suid-Afrikaanse vroulike atlete nie.

Sleutelwoorde: Vroulike atleet-triade, amenorree, eetversteurings, adolessente, atlete, uithou-atlete, oefening, LMI, oefenvolume, liggaamsamestelling, osteoporose, antropometrie, BOD POD, menarg.

Table of Contents

◆ Foreword	i
◆ Declaration	iv
◆ Summary	v
◆ Opsomming	vii
◆ Table of contents	ix
◆ List of figures	xiv
◆ List of tables	xv
◆ List of abbreviations	xvi

CHAPTER 1

THE PROBLEM STATEMENT AND THE AIM OF THE STUDY

1.1 INTRODUCTION	2
1.2 PROBLEM STATEMENT	4
1.3 OBJECTIVES	7
1.4 HYPOTHESES	7
1.5 STRUCTURE OF THE DISSERTATION	8
1.6 REFERENCES	10



CHAPTER 2

THE RELATIONSHIP BETWEEN EXERCISE, AMENORRHOEA, PERCENTAGE BODY FAT, AND DISORDERED EATING IN FEMALES

	(Review article)	
2.1	INTRODUCTION	15
2.2	ELEMENTS ASSOCIATED WITH THE FEMALE TRIAD	17
2.2.1	Disordered eating	19
2.2.2	Amenorrhoea	20
2.2.3	Osteoporosis	22
2.3	EXERCISE AND THE FEMALE ATHLETE TRIAD	24
2.3.1	Exercise and menstrual cycle disorders	25
2.3.2	Exercise and body composition	27
2.3.3	Exercise and disordered eating	28
2.4	CONCLUSION	30
2.5	REFERENCES	31

CHAPTER 3

BODY COMPOSITION, DISORDERED EATING, AND MENSTRUAL DYSFUNCTION IN YOUNG FEMALE ATHLETES

	(Research article)	
	SUMMARY	40
3.1	INTRODUCTION	41
3.2	METHODS	44
3.2.1	Subjects	44
3.2.3	Anthropometrics measurements	45

3.2.3 Body composition assessments	45
3.2.4 Menstrual status	45
3.2.5 Eating patterns and attitudes	46
3.2.6 Statistical analysis	47
3.3 RESULTS	47
3.3.1 Anthropometrics measurements	47
3.3.2 Menstrual status	48
3.3.3 Eating patterns and attitudes	49
3.3.3.1 <i>EAT – 26</i>	49
3.3.3.2 <i>Eating Disorder Inventory</i>	50
3.4 DISCUSSION AND CONCLUSION	51
3.5 ACKNOWLEDGEMENTS	56
3.6 REFERENCES	57

CHAPTER 4

TRAINING VOLUME AND MENSTRUAL DYSFUNCTION IN YOUNG FEMALE ATHLETES

(Research article)

SUMMARY	67
4.1 INTRODUCTION	68
4.2 METHODS	70
4.2.1 Subjects	70
4.2.2 Menstrual status	70
4.2.3 Training volume	71
4.2.4 Statistical analysis	71
4.3 RESULTS	71
4.3.1 Menstrual status	71

4.3.2 Training volume	73
4.4 DISCUSSION AND CONCLUSION	78
4.5 ACKNOWLEDGEMENT	80
4.6 REFERENCES	81

CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS	85
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5.1 SUMMARY	86
5.2 CONCLUSIONS	87
5.3 RECOMMENDATIONS	88
5.4 FUTURE RESEARCH	90

APPENDICES	91
-------------------	-----------

Appendices A

◆ Guidelines for Authors	92
○ Journal of Human Movement Studies	93

Appendices B

◆ Ingeligte toestemmingsvorm	97
◆ Informed consent	99

Appendices C

◆ Questionnaires	103
➤ Personal Information	104
➤ Menstrual History Questionnaire	105
➤ Training Volume Questionnaire	107
➤ Exercise Dependence Questionnaire	109

➤ Eating Attitudes Test (EAT-26) Questionnaire_____	111
➤ Eating Disorder Inventory (EDI) Questionnaire_____	113

Appendices D

◆ Anthropometric Performance_____	117
-----------------------------------	-----



List of Figures

CHAPTER 1

- Figure 1.1** The female athlete triad_____6
- Figure 1.2** Structure of dissertation_____9

CHAPTER 2

- Figure 2.1** The female athlete triad_____16
- Figure 2.2** The corners of the female athlete triad (osteoporosis, disordered eating and amenorrhea) are inter-related through psychological and physiological mechanisms____18
- Figure 2.3** Bone mineral densities of amenorrhoeic and normally menstruating athletes_____23
- Figure 2.4** Bone density of a competitive female runner against a 69 year-old elderly woman_____24

CHAPTER 4

- Figure 4.1** Frequency of training sessions per week_____73
- Figure 4.2** Athletes' training sessions per week_____76
- Figure 4.3** Athletes' training sessions per day_____77



List of Tables

CHAPTER 3

Table 3.1	Anthropometric measurements of female athletes_____	47
Table 3.2	Chronological and age of menarche of the three groups__	48
Table 3.3	Menstrual regularity of the total group and individual groups of athletes_____	49
Table 3.4	Descriptive statistics for the Eating Disorder Inventory (EDI) and the Eating Attitude Test (EAT-26) of the three groups of athletes_____	50

CHAPTER 4

Table 4.1	Chronological and age of menarche of the three groups__	72
Table 4.2	Menstrual regularity of the total group and individual groups of athletes_____	72
Table 4.3	Length of training sessions_____	74
Table 4.4	Athletes' training sessions per week_____	75
Table 4.5	Athletes' training sessions per day_____	75
Table 4.6	Length of training sessions_____	76



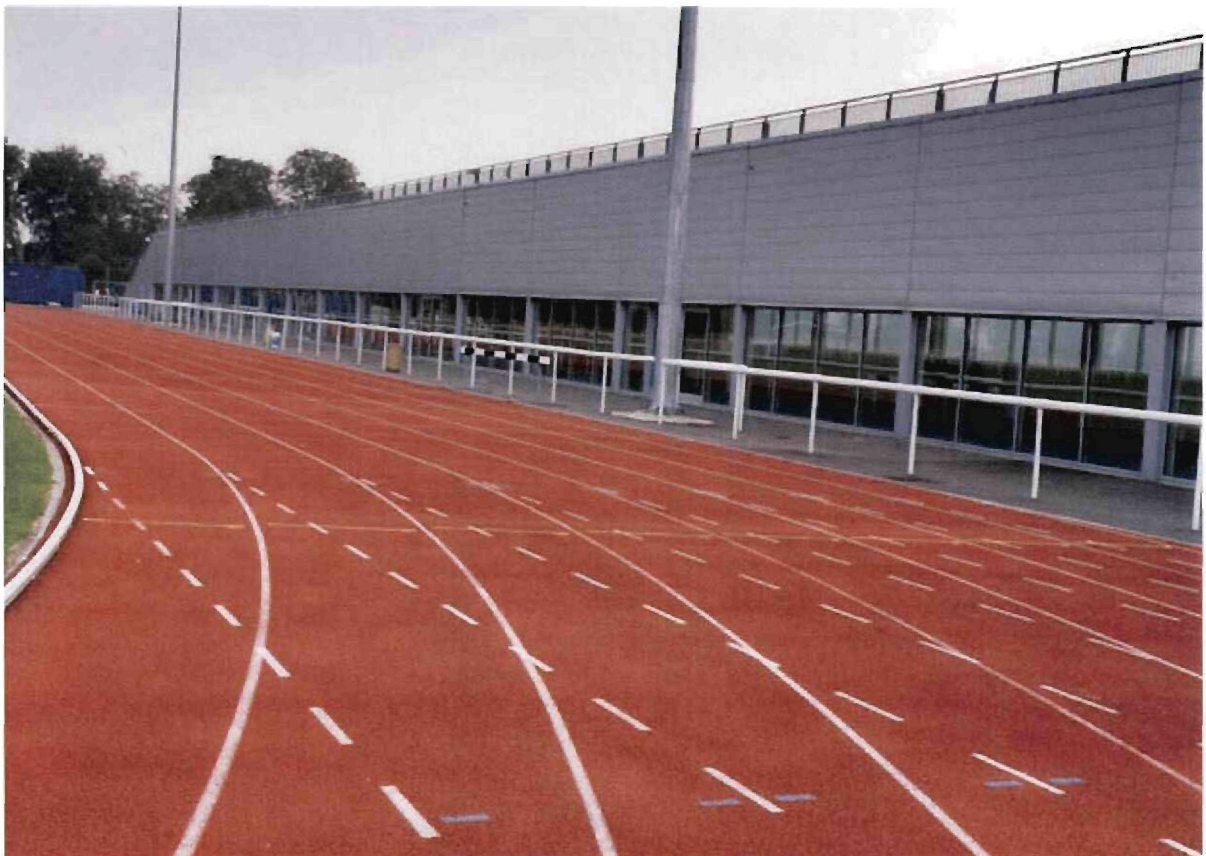
List of Abbreviations

ACSM	American College of Sports Medicine
ADP	Air Displacement Plethysmography
ANOVA	Analysis of variance
BD	Body density
BMD	Bone mineral density
BMI	Body Mass Index
cm	Centimeters
cycles/yr	Cycles per year
DE	Disordered eating
ED	Eating disorder
EAT-26	Eating Attitude Test – 26
EDI	Eating Disorder Inventory
EDNOS	Eating disorder not otherwise specified
e.g.	Example
<i>et al.</i>	And others
FFM	Fat free mass
ISAK	International Standards for Anthropometrics Assessments
ml	Milliliter
NCAA	National Collegiate Athletic Association
g/cm ²	Gram per square centimeter

hours/week	Hours per week
kcal/kg	Kilocalory per kilogram
kg	Kilogram
kg/m ²	Kilogram per square meter
kJ/kg	Kilojoules per kilogram
km/week	Kilometres per week
n	Total
SD	Standard deviation
WHO	World Health Organization
yr	Years

Chapter 1

*The problem statement and the aim
of the study*





The problem statement and the aim of the study

- 1.1 INTRODUCTION
 - 1.2 PROBLEM STATEMENT
 - 1.3 OBJECTIVES
 - 1.4 HYPOTHESES
 - 1.5 STRUCTURE OF THE DISSERTATION
 - 1.6 REFERENCES
-

1.1 INTRODUCTION

Irregular menses have been reported to range from 1% to 66% among athletes, compared with 2% to 5% of the general population (Burrows & Bird, 2000:285; Harmon, 2002:34). The wide range of reported menstrual abnormalities stems not only from different populations surveyed, but also from different criteria used to define the condition (Harmon, 2002:34). Interrelationships among nutrition, exercise intensity and volume, body mass index and psychological stressors contribute to normal menstrual function (Harmon, 2002:30).

The female athlete triad was first officially defined in 1993 by a panel of experts who identified a spectrum of disordered patterns of eating and amenorrhoea in female athletes (Yeager *et al.*, 1993:776). In the position stand by the American College of Sports Medicine (ACSM) (1997), these ideas were further defined to include three distinct components: (a) disordered eating, (b) amenorrhoea, and (c) osteoporosis (Otis *et al.*, 1997:3; Hobart & Smucker, 2000:3360). Papanek (2003:600) reports that the meeting was called in response to the alarming increase in stress fracture rates, documented decreases in bone mineral density and menstrual dysfunction in otherwise healthy female athletes. Furthermore, the depiction of the triad as a triangle was developed to

demonstrate the interrelationship between the three disorders normally considered to be independent medical conditions (Papanek, 2003:600-602).

The female athlete triad is not a very common condition, but is a very serious one (Peoria, 2001:12). The term refers to a young woman athlete who trains rigorously and has a combination of an eating disorder; amenorrhoea (the absence of menstruation) and osteoporosis, or bone weakness (Hobart & Smucker, 2000:3357; Peoria, 2001:10; Barr & Rideout, 2004:696, Birch, 2005:244). Typically, young athletes with these conditions – or those who are at risk for these conditions – may severely restrict what they eat or binge and purge in order to lose weight or remain thin (Otis *et al.*, 1997:2; Peoria, 2001:14). In addition to having an eating disorder, these young athletes may exercise much more intensely or longer than is required for normal training (Peoria, 2001:15).

Epidemiological studies have shown rates of triad as high as 62% in female athletes (De Souza, 2003:1558; Warren, 2007:1393). Athletes most at risk are those participating in sports such as figure skating and dancing where appearance is judged, or sports in which low body weight is the norm, such as distance running and gymnastics (De Souza, 2003:1558; Warren *et al.*, 2003:401).

Amenorrhoea can occur in the context of eating disorders or exercise (Rome, 2003:360). DiPietro and Stachenfeld (1997:2) support this by adding that a chronic negative energy balance, being underweight and exercise stress are important elements in the pathway to amenorrhoea. Cobb (2003:715) write that female athletes with disordered eating may limit their calorie and/or fat intakes but maintain high training levels, often resulting in a state of chronic energy deficit. Athletic amenorrhoea occurs more frequently in activities such as long distance running, ballet and gymnastics, in which intense physical training is combined with the desire to maintain a lean build (Beals & Manore, 2002:285; Harmon, 2002:34; De Souza, 2003:1558).

Continuing the triad syndrome's assault on the female athlete's wellness is the relationship between the absence of menses and bone deterioration. There is a prevailing myth in women's athletics that equates a disrupted menstrual cycle with the appropriate level of elite training (Papanek, 2003:611), while others regard it as a great solution to a monthly inconvenience (National Institute of Health, 2003).

1.2 PROBLEM STATEMENT

Body composition is important for optimal physical performance in many sports (Heyward & Wagner, 2004:708). In long distance running specifically, a lean body is regarded as a prerequisite for optimum performance (Greydanus & Patel, 2002:571). According to Greydanus and Patel (2002:558), the pressure to obtain the "ideal" body along with the intense exercise requirement of athletes could lead to the female triad. The female triad can be defined as a syndrome consisting of three components: disordered eating, amenorrhoea and osteoporosis (Otis *et al.*, 1997:9; Barr & Rideout, 2004:694).

The popularity of competitive sports and the number of women that are taking part in sports and especially in top-level competition have increased substantially in recent times (Donaldson, 2003:322). Exercise has many benefits, namely mental and physical advantages (Warren, 1999:1893; Sambanis *et al.*, 2003:401). However, excessive training may lead to health problems in the long term, including menstrual dysfunction, especially in women who practice athletics, rhythmic gymnastics and dance (Warren, 1999:1894; Sambanis *et al.*, 2003:400). Irregular menses have been reported to range from 1% to 66% among athletes, compared with 2% to 5% of the general population (Burrows & Bird, 2000:285; Harmon, 2002:53). Primary amenorrhoea is defined as the absence of menstruation by age 16 in a girl with well-developed secondary sex characteristics; secondary amenorrhoea is the absence of three or more consecutive menstrual cycles after menarche; and oligomenorrhoea is defined as less or equal to six menses per year (Harmon, 2002:50; Warren *et al.*, 2002:513; Sherman & Thompson, 2004:199).

Amenorrhoea is a relatively common disorder with a prevalence that has been difficult to determine because of the variability in definition (West, 1998:66). Amenorrhoea has been reported to be between 3,4% to 66% in some segments of the athletic population (West, 1998:66).

The intensity of exercise and low energy consumption, specific type and amount of training, early age of reaching top level of performance, previous menstrual dysfunctions, low body mass index (BMI) or percentage body fat, pathological eating habits and psychological stress have been suggested as potential factors accountable for menstrual irregularities in female athletes (Malina, 1999:295; Beunen *et al.*, 1999:285; Manore, 2002).

Strenuous physical activity may affect the female reproductive system, which can lead to athletic amenorrhoea (Warren, 1999:1894; Cobb, 2003:711). The term athletic amenorrhoea refers to amenorrhoea that cannot be explained by any known aetiology other than the exercise training, and therefore its determination is made by exclusion. The prevalence of amenorrhoea among athletes is 4-20 times higher than among the general population (De Cree, 1998:372; De Souza, 2003:1558; Warren, 2007:1393), and appears to be higher (67% vs. 9%) in younger athletes who train intensively, and in certain types of sports in which leanness may provide a competitive advantage (Redman & Loucks, 2005:747). One of the major concerns of athletic amenorrhoea is the low oestrogen levels, which despite the relative protection by the weight-bearing activity, may result in reduced bone mass, due to inadequate acquisition of peak bone mass during the critical period of puberty, and/or due to excessive bone loss in later years. The resulting osteopenia may expose the young female athlete to an increased risk of skeletal fragility, fractures and vertebral instability and curvature (Hobart & Smucker, 2000:3357).

All female athletes are at risk for developing the triad; but the actual magnitude of the problem is unknown (Sanborn *et al.*, 2000:212). The actual prevalence of the female athlete triad is unknown (Hobart & Smucker, 2000:3364), because of the secretive nature

of the disordered eating component and underreporting by female athletes (Sanborn *et al.*, 2000:211).

In this study, the aim is to provide a practical way of assessing the first signs of the female athlete triad in order to easier identify and refer athletes at risk. This will be done by assessing eating behaviours, the prevalence of amenorrhoea, exercise history and body composition.

The questions to be answered in this study are firstly if menstrual dysfunction has any association with body composition and disordered eating in 14 – 25 year-old female athletes and secondly if menstrual dysfunction has any association with training volume in 14 – 25 year-old female athletes. These questions could possibly help to describe the role that body composition, eating disorders and training volume plays in the prevalence of amenorrhoea.

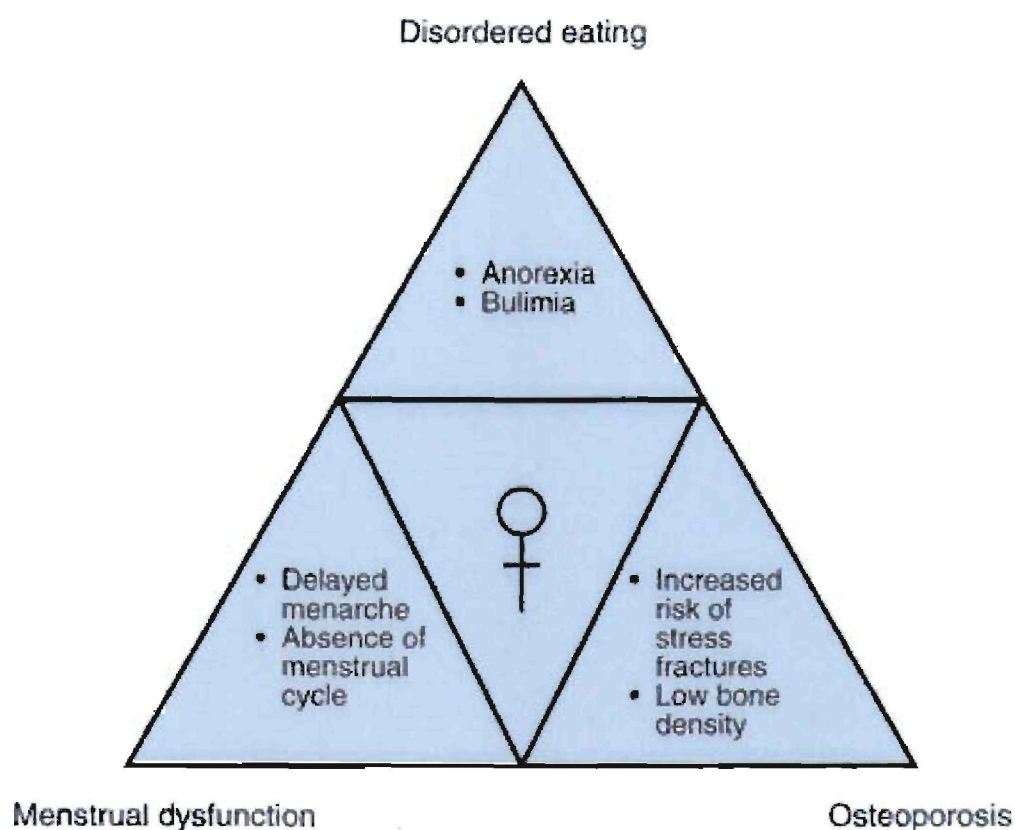


Figure 1.1. The female athlete triad (From Drinkwater *et al.*, 2000).

1.3 OBJECTIVES

The aims of the study are to determine if there is:

- A relationship between body compositions, and menstrual dysfunction among 14 – 25 year-old female athletes;
- A relationship between disordered eating and menstrual dysfunction among 14 – 25 year-old female athletes; and
- A relationship between training volume and menstrual dysfunction among 14 – 25 year-old female athletes.

1.4 HYPOTHESES

This study is based on the following hypotheses:

- There is a positive relationship between body composition and menstrual dysfunction in 14 – 25 year-old female athletes.
- There is a positive relationship between disordered eating and menstrual dysfunction in 14 – 25 year-old female athletes.
- The training volume of the female athlete plays a significant role in the prevalence of menstrual dysfunction.

1.5 STRUCTURE OF THE DISSERTATION

When the literature was studied it became clear that more information was needed on the prevalence of amenorrhoea in 14 - 19 year-old middle and long distance female athletes.

This dissertation is presented in four main parts, namely an introduction (Chapter 1), a review article (Chapter 2) and two research articles (Chapter 3 & 4). A summary with a discussion, a conclusion and recommendations will follow in Chapter 5. The introduction presents the problem statement, objectives and hypotheses. The articles were each written according to the instructions to authors of the journal to which the article will be submitted. The review article (Chapter 2) is based the components of female triad and physical activity. The research article (Chapter 3), investigates the association between body composition, disordered eating and menstrual dysfunction, while Chapter 4 investigates the relationship between training volume and menstrual dysfunction in female athletes. The results of the studies in Chapter 3 and 4 are presented and interpreted in each chapter respectively and then summarised in Chapter 5, together with conclusions and recommendations. Chapter 5 is followed by a list of appendices.

The structure of the dissertation is shown in Figure 1.2.

Figure 1.2
Structure of the dissertation

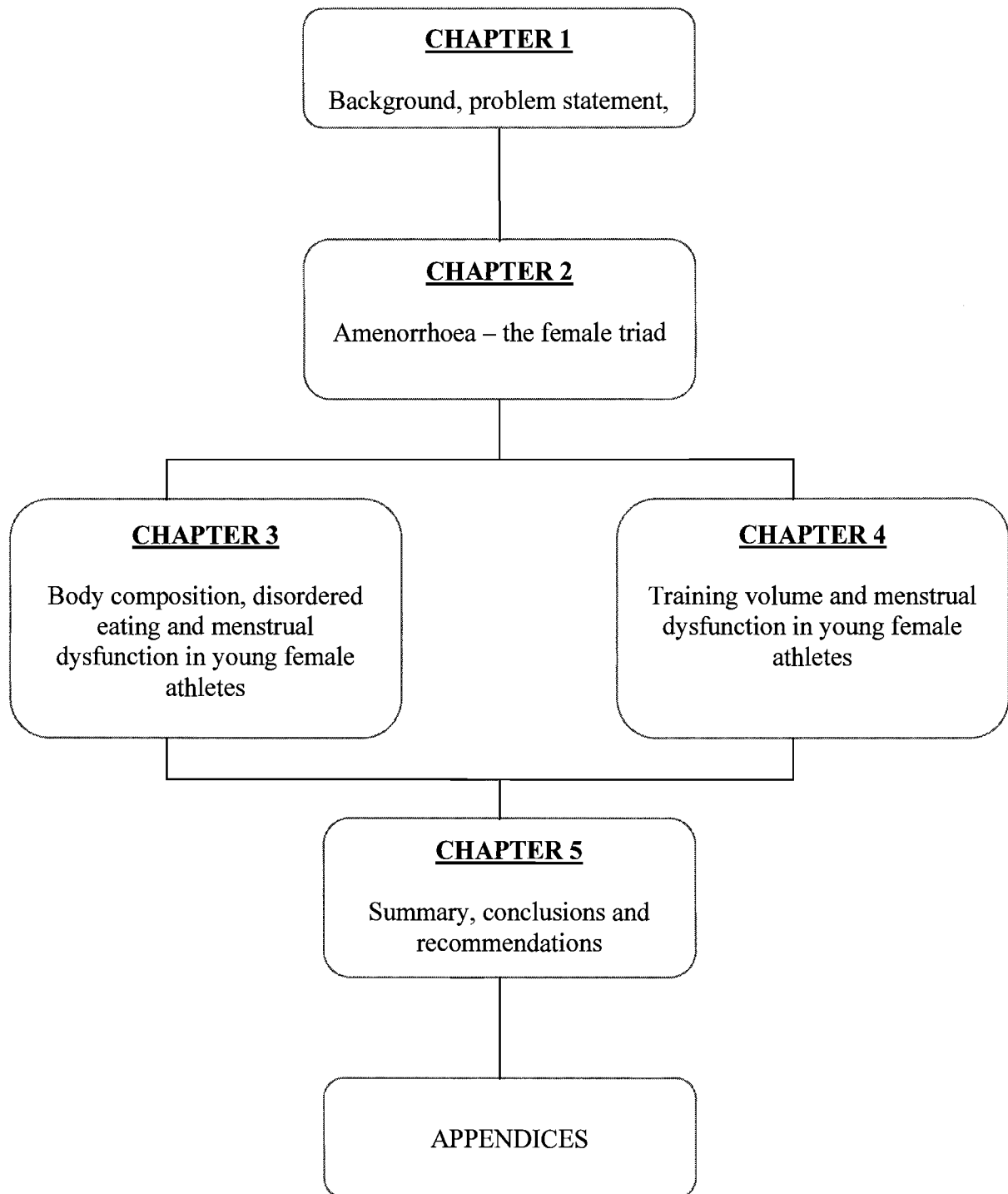


Figure 1.2: Structure of the dissertation

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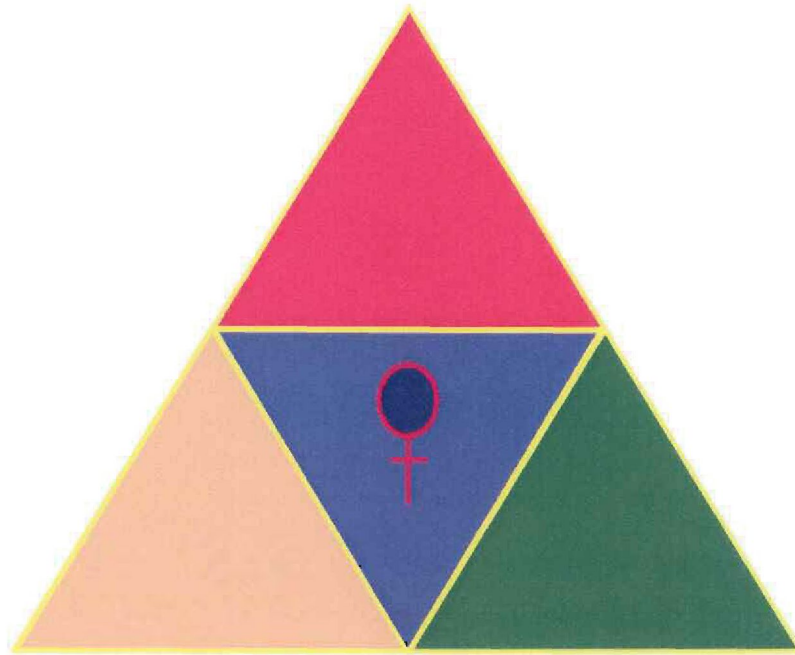
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Chapter 2

*The relationship between exercise,
amenorrhoea, percentage body fat
and disordered eating in females*

Disordered Eating



Amenorrhea

Osteoporosis

2

The relationship between exercise, amenorrhoea, percentage body fat and disordered eating in females

- 2.1 INTRODUCTION
- 2.2 ELEMENTS ASSOCIATED WITH THE FEMALE TRIAD
 - 2.2.1 Disordered eating
 - 2.2.2 Amenorrhoea
 - 2.2.3 Osteoporosis
- 2.3 EXERCISE AND THE FEMALE ATHLETE TRIAD
 - 2.3.1 Exercise and menstrual cycle disorders
 - 2.3.2 Exercise and body composition
 - 2.3.3 Exercise and disordered eating
- 2.4 CONCLUSION
- 2.5 REFERENCES

2.1 INTRODUCTION

The opportunities for adolescent girls and young adult women to participate at all levels of sports competition have increased substantially since the institution of Title IX in 1972 (Nattiv *et al.*, 1994:405; Vinci, 1999:16-17; Hobart & Smucker, 2000:3357; Hinton & Kubas, 2005:149). Twenty-five years ago, only 16 000 women participated in intercollegiate athletics. By 2001, more than 157 000 women competed in National Collegiate Athletics Association (NCAA)-member teams and according to Hinton and Kubas (2005:149), the numbers are still growing. This trend can be regarded as a positive sign for women's health because with increased physical activity comes associated wellness benefits. Willmore and Costill (1999:60) indicate that chronic physiological adaptation to exercise training has been well-documented with regard to

improved cardiovascular efficiency, muscular strength, self-esteem and overall body image.

Ramos and Lola (2004:63) claim that there are many non-competitive women who also exercise vigorously. This mindset results in training becoming a lifestyle philosophy as well as a passion. While this is generally an admirable trait, it is not without significant risk. For example, over-training injuries in the form of muscular strain, tendonitis and stress fractures will likely occur in many individuals, as well as competitively trained athletes who overexert themselves at the expense of sufficient recovery and nutrition (De Oliveira *et al.*, 2003:357; Ramos & Lola, 2004:58). There is ample evidence that for young women, there is a greater health concern that far outweighs the typical “overuse syndrome”, called the female athlete triad (Otis *et al.*, 1997:3; Robert & Rebar, 2003:7-9; Ramos & Lola, 2004:61). Fig 2.1 illustrates the full range of the Triad.

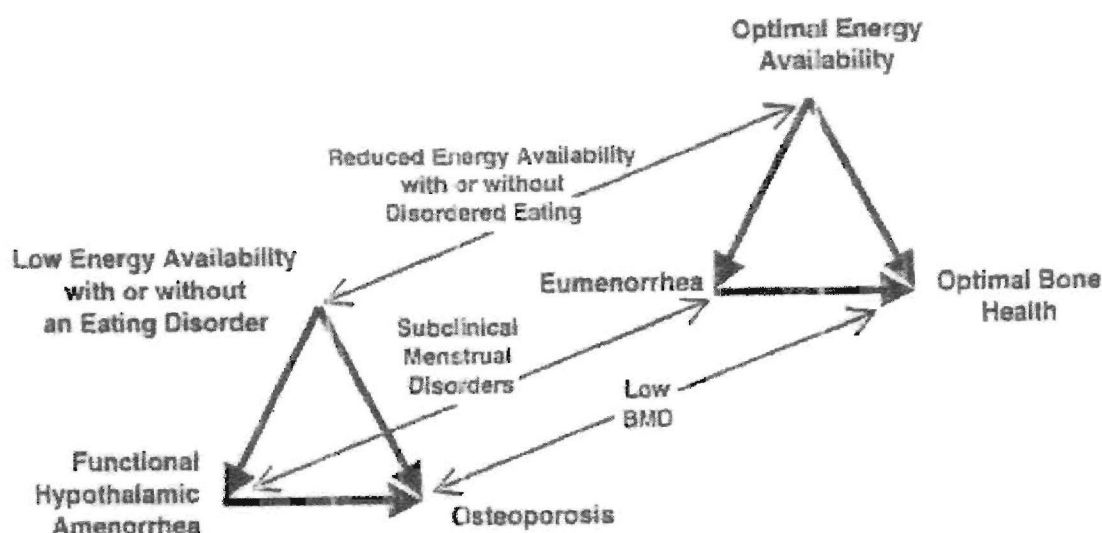


Figure 2.1: The female athlete triad. The spectrum of energy availability, menstrual function, and bone mineral density along which female athletes are distributed (narrow arrows). An athlete’s condition moves along each spectrum at a different rate, in one direction or the other, according to her diet and exercise habits. Energy availability, defined as dietary energy intake minus exercise energy expenditure, affects bone mineral density both directly via metabolic hormones and indirectly via effects on menstrual function and thereby estrogen (thick arrows) (Nattiv *et al.*, 2007).

The female athlete triad refers to three interrelated conditions, namely disordered eating, amenorrhoea and osteoporosis (Hobart & Smucker, 2000:3357; Cobb *et al.*, 2003:711; Barr & Rideout, 2004:696; Birch, 2005:244). While on its own each portion of the triad increases the chance of morbidity and mortality, the danger of the three together increases this chance (Otis *et al.*, 1997:iii; West, 1998:66; Beals *et al.*, 1999:338; Hobart & Smucker, 2000:3357). In endurance sports, a low body fat (11 – 22%) is desirable because it is believed to enhance performance (Wolf *et al.*, 1997:295; Stokic *et al.*, 2005:195) and therefore all female athletes that are participating in such events are at risk for developing the triad (Sanborn *et al.*, 2000:200; Greydanus & Patel, 2002:553). According to Hobart and Smucker (2000:3360), the actual magnitude of the triad is unknown, mostly because of the secretive nature of the disordered eating component and underreporting by female athletes in this regard (Sanborn *et al.*, 2000:201; Hebert & McClean, 2003:573). It is therefore necessary to discuss the influence of exercise and/or physical activity on the various components of the triad.

2.2 ELEMENTS ASSOCIATED WITH THE FEMALE TRIAD

The female athlete triad has long been recognised as a syndrome that has the potential to affect female athletes. It consists of three inter-related elements: disordered eating, amenorrhoea, and osteoporosis. The potential impact of each and the combination of these disorders are regarded as detrimental to women's performance and their health (Birch, 2005:244).

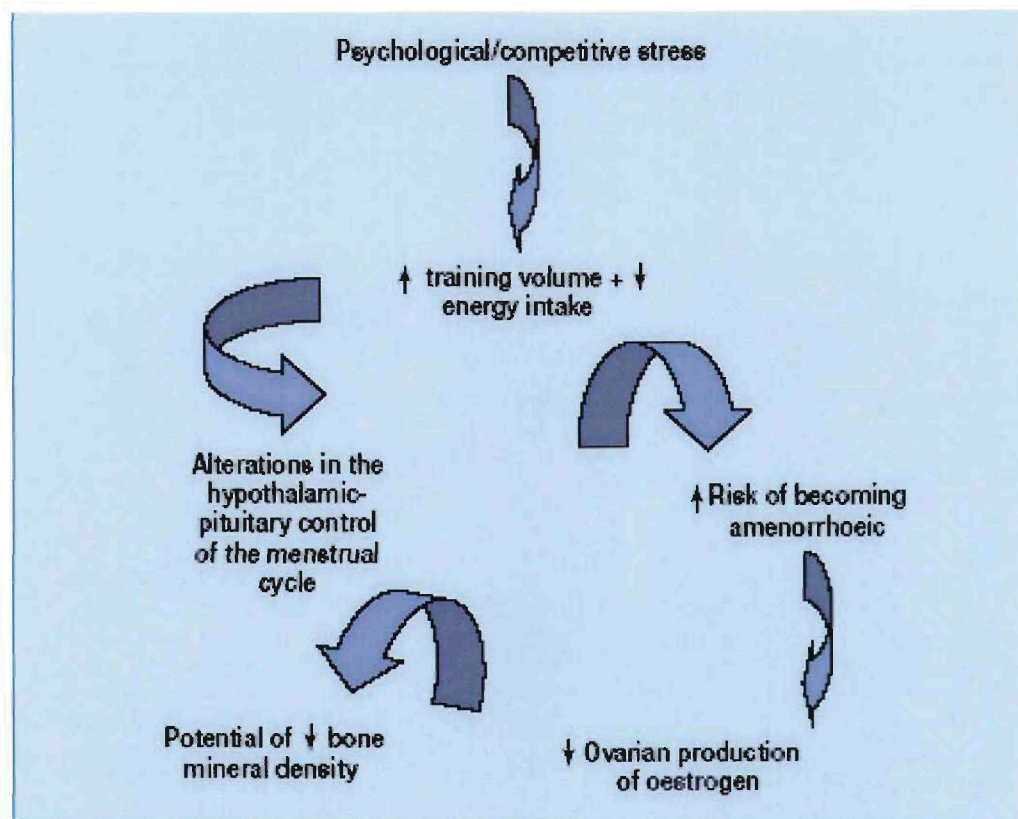


Figure 2.2: The corners of the female athlete triad (osteoporosis, disordered eating and amenorrhoea) are inter-related through psychological and physiological mechanisms (Birch, 2005).

The three corners of the triad are inter-related through psychological and physiological mechanisms, as illustrated in Figure 2.2. The psychological pressures to perform to an optimal level during exercise or competition, and thus often a personally perceived requirement to maintain a low body mass, result in a high volume of training (Birch, 2005:244). The high volume of training and low energy intake, in addition to stress hormones produced by psychological stress, may lead to a physiological alteration in the endocrinological control of the menstrual cycle, which may ultimately lead to the athlete becoming amenorrhoeic (Birch, 2005:244). The consequence of being amenorrhoeic through dysfunction of the hypothalamus and pituitary gland is a decreased production of oestrogen. This hormone plays a major role in maintaining adequate bone mineral density, as a hypo-oestrogenic state (low oestrogen) is associated with low bone mineral density and an increased risk of osteoporosis (Birch, 2005:244).

The different components of the female triad will now be discussed.

2.2.1 Disordered eating

The term “disordered eating” is preferred to “eating disorder”, as it implies a spectrum of abnormal behaviour that at its extreme includes anorexia nervosa and bulimia nervosa (Beals *et al.*, 1999:339; Hobart & Smucker, 2000:3358; Klopp *et al.*, 2003:745). Disordered eating occurs in 5% of the general population (Donaldson, 2003:330), but affects as many as two thirds of young female athletes (Joy *et al.*, 1997:98; Putukian, 1998:678; Anderson *et al.*, 2000:612; Hobart & Smucker, 2000:3361; Sundgot-Borgen & Torstveit, 2004:25), because they are potentially driven by a need to maintain a low body weight for performance.

Disordered eating, which includes skipping meals, eating less, vomiting, the use of laxatives and diuretics, describes a broad range of behaviours used to maintain or lose weight (Sanborn *et al.*, 2000:211; Papanek, 2003:601; Birch, 2005:245; Nichols *et al.*, 2006:690; Ronco, 2007:22). Another common disordered eating behaviour is to restrict the intake of certain foods, particularly those high in fat and/or protein (Otis *et al.*, 1997:2; Sanborn *et al.*, 2000:199; De Oliveira *et al.*, 2003:358). Other disordered eating behaviours include binge eating and/or purging. Purging includes not only self-induced vomiting but also the use of diet pills, laxatives, and diuretics, as well as an increase in exercise (Sanborn *et al.*, 2000:199; Donaldson, 2003:323; Ronco, 2007:22).

Although it has been reported that disordered eating involving acute body weight fluctuation (4,5 kg loss and regain) has been associated with amenorrhoea (Cobb *et al.*, 2003:711), it has been confirmed by Loucks *et al.* (1998:38) that there is no specific percentage body fat below which regular menstruation ceases. Some athletes with amenorrhoea regain their menstrual cycle after intervals of rest, even without an increase in bodyweight or body fat, suggesting that amenorrhoea is not caused solely by low bodyweight or body fat (Loucks *et al.*, 1998:38; Drinkwater *et al.*, 2000:18). In an investigation, De Souza and Williams (2004) suggest that reduced energy availability can be regarded as the main cause of the central suppression of the hypothalamic pituitary-

gonadal axis. They define energy availability as dietary energy intake minus energy expenditure and demonstrate that the relationship between energy expenditure and caloric intake and not each component separately, is the major factor that alters both metabolic and reproductive hormone secretion in elite athletes. Furthermore, it was also found that there is an energy availability threshold of 20-25 kcal/kg lean body mass, and that menstrual disturbances occur only in female athletes who have energy availability below this threshold (Manore, 1999:551; Elford & Spence, 2002:85, Redman & Loucks, 2005:751).

Disordered eating associated with training and sport performance has been distinguished from pathological anorexia by the use of the term 'anorexia athletica' (Birch, 2005:245). The criteria for 'anorexia athletica' in athletes include perfectionism, compulsiveness, competitiveness, high self-motivation, menstrual disturbances and at least one unhealthy method of weight control (Birch, 2005:245). Athletes in this 'anorexia athletica' category will show signs of disordered eating, as opposed to an eating disorder, and clinical observations indicate a prevalence of 15 – 60% for disordered eating, with 50% of these women compulsively over-exercising (Birch, 2005:245).

For female athletes who participate in aesthetical-acrobatic activities and strenuous endurance sports, low body fat is desirable because it is believed to enhance performance (Stokic *et al.*, 2005:195). Manore (2002:890) reports that for many female athletes, constant energy restriction has become a normal part of their lifestyle and is one of the primary factors contributing to menstrual dysfunction in this population.

2.2.2 Amenorrhoea

Amenorrhoea is defined as the 'absence of menstrual bleeding' and can be classified as either primary or secondary (West, 1998:65; Beals *et al.*, 1999:339; American Academy of Pediatrics, 2000:610; Hobart & Smucker, 2000:3357). The Practice Committee of the American Society of Reproductive Medicine (2004) has recently defined primary amenorrhoea as the absence of menstrual cycles in a girl who has not menstruated by 16 years of age, even though she has undergone other normal changes that occur during

puberty. Secondary amenorrhoea refers to the absence of three or more consecutive menstrual cycles after menarche (Hobart & Smucker 2000:3357; Otis & Goldingay, 2000; Warren & Goodman, 2003:875; Practice Committee of the American Society for Reproductive Medicine, 2004:268). In an attempt to standardise future reports, the International Olympic Committee has defined amenorrhoea as 1 menstrual period or less per year. Amenorrhoea is a relatively common disorder among female athletes with a prevalence that has been difficult to determine because of the variability in definition (West, 1998:65).

Amenorrhoea has been reported to occur between 3,4% to 66% in the athletic population (West, 1998:66). A number of factors, such as energy balance, disordered eating behaviours, exercise intensity and training practices, body weight and composition, and physical and emotional stress may contribute to the development of athletic menstrual dysfunction, resulting in amenorrhoea (Manore, 2002). These factors may cause hypothalamic dysfunction and suppression of the spontaneous pulsatile secretion of the gonadotropin-releasing hormone (Redman & Loucks, 2005:749). Several mechanisms have been suggested to explain this suppression. It has been suggested that the later age of menarche in female athletes is due to genetic factors, since non-athletic mothers and sisters of female amenorrhoeic athletes also have a higher prevalence of menstrual abnormalities (Malina *et al.*, 1994:417; Redman & Loucks, 2005:750). Genetic factors, however, cannot explain such a higher prevalence (up to 20 times) of menstrual dysfunctions above the general population (Malina *et al.*, 1994:417; Redman & Loucks, 2005:750).

Numerous studies have associated the prevalence of menstrual cycle irregularity with the age of the athletes, low body fat percentage, bodyweight changes, training intensity, age at menarche, intense training before menarche, prior menstrual cycle irregularities, prior training histories, the endocrine conditioning model, the energy drain theory, pregnancy and endogenous opioids (Bale, 1994:348; Burrows & Bird, 2000:21). However, research indicates that menstrual disturbances may not be caused by bodyweight loss or low body fat levels alone, but can be combined with a host of other factors already mentioned.

Indeed, Keizer and Rogol (1990:219) and Prior *et al.* (1990:125) state that no one factor can be singled out as the primary cause of menstrual cycle dysfunction and that athletic amenorrhoea results from a manifestation of nutritional deprivation, physical illness, stress and excessive exercise (Burrows & Bird, 2000:21).

The athletic female who experiences a disruption in her menstrual cycle is at great risk for developing osteoporosis (Hobart & Smucker, 2000:3357).

2.2.3 Osteoporosis

Osteoporosis, the third component of the female triad, refers to inadequate bone formation and premature bone loss, resulting in low bone mass and increased risk of fracture (Beals *et al.*, 1999:339; Sanborn *et al.*, 2000:202 Hobart & Smucker 2000:3357). In the case of the active athlete, premature osteoporosis puts the athlete at risk for stress fractures as well as more devastating fractures of the hip or vertebral column (Hobart & Smucker, 2000:3357). Osteoporosis affects 25 million individuals in the United States of America alone and causes 1, 5 million fractures each year (West, 1998:66). Osteoporosis can occur if the bone mineral density (BMD) is less than 2,5 standard deviations below the mean value for a specific age group (O'Brien, 2001:59; Khan *et al.*, 2002:11; Waldrop, 2005:215; Birch, 2005:245). Birch (2005:244) claims that women with low energy availability and low oestrogen concentrations have increased risk of becoming osteoporotic.

The risk for developing osteoporosis is greater in female athletes if there is a disruption in their menstrual cycles (Sanborn *et al.*, 2000:202). This may be partially irreversible, despite resumption of menstruation, oestrogen replacement or calcium supplementation (Warren *et al.*, 2002:515; Cobb *et al.*, 2003:711; De Souza & Williams, 2004:19).

It has been found that both athletic and non-athletic women with amenorrhoea have lower vertebral BMD compared with healthy women (Rencken *et al.*, 1996:239; Ronco, 2007:22). De Souza and Williams (2004:10) report that the vertebral BMD was significantly lower in athletes with a history of irregular menses and that a linear

relationship existed between irregularity and vertebral BMD. De Souza and Williams (2004:10) also report that vertebral BMD in athletes with amenorrhoea was 20% lower than that of healthy athletes and 10% lower than that of non-athletes of a similar age with a normal menstrual cycle, as shown in Figure 2.3.

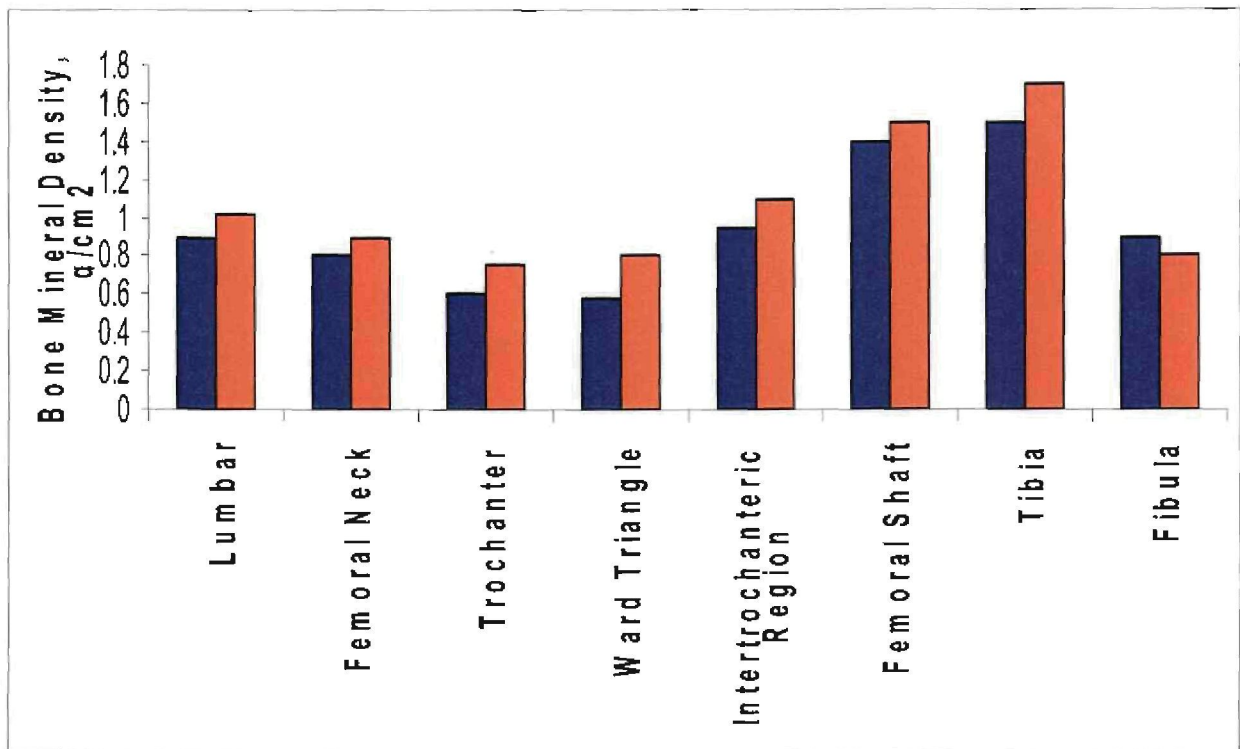


Figure 2.3: Bone mineral density of amenorrhoeic (blue/dark bars) and normally menstruating athletes (orange/light bars). From: De Souza & Williams (2004:10).

According to Snow-Harter (1994:400), some women with exercise-induced amenorrhoea have a bone density typical of that found in an elderly woman, as illustrated in Figure 2.4.



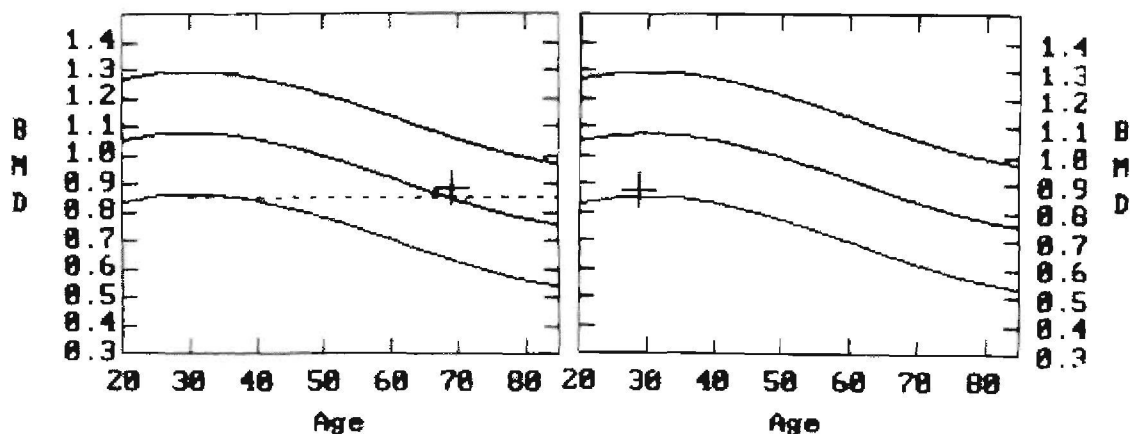


Figure 2.4: Bone density of a competitive female runner (right) against a 69 year-old woman (left). (Snow-Harter, 1994:400).

The cross in the right panel illustrates the bone density of a 28 year-old competitive female runner. The subject had normal menstrual cycles at the time of the bone scan, but had an 8 year history of exercise-induced amenorrhoea. Her spine bone density (0.874 g/cm^2) is nearly equivalent to that of 69 year-old woman (0.877 g/cm^2) depicted by the cross in the left panel. The older woman's spine density, according to Snow-Harter (1994:400), is average for her age, but the runner's spine density is well below the average value for her age (Snow-Harter, 1994:400).

2.3 EXERCISE AND THE FEMALE ATHLETE TRIAD

There appears to be an increasing number of children who specialise in a sport at an early age, train year-round for a sport, and compete at an elite level (Committee on Sports Medicine and Fitness, 2000:154). To be competitive at a high level requires training regimens for children that could be considered extreme, even for adults. The ever-increasing requirements for performance creates a constant pressure for athletes to train longer, harder, more intelligently and in some cases at an earlier age (Committee on Sports Medicine and Fitness, 2000:154). The necessary commitment and intensity of

training raised concerns about the sensibility and safety of high-level athletics for any young person (Committee of Sports Medicine and Fitness, 2000:154).

Regular exercise may result in physiological and psychological benefits and is recommended in both the prevention and treatment of physical disorders/conditions such as coronary heart disease, hypertension and obesity as well as psychological problems such as depression and anxiety (Otis & Goldingay, 2000; Vardar *et al.*, 2005:550; Ronco, 2007:22). However, the literature suggests that exercise may also have harmful effects on the individual, particularly in terms of exacerbating physical injuries (Zeni-Hoch *et al.*, 2003:379; De Souza & Williams, 2004:01). Most individuals who participate in sport and exercise have a positive experience, providing and improving physical fitness and better health (De Souza & Williams, 2004:01). Yet, for some women, the desire for athletic success, combined with the pressure to achieve a desired body weight, may lead to the development of medical disorders, namely eating disorders, amenorrhoea and osteoporosis, collectively known as the female athlete triad (ACSM, 1997:5; Cobb *et al.*, 2003:711). The interaction between exercise and these factors associated with the female athlete triad will be discussed briefly.

2.3.1 Exercise and menstrual cycle disorders

Whilst there is no published research supporting the myth that vigorous exercise during menstruation can have a direct, long term detrimental effect on the female reproductive system, research has suggested an association between vigorous training and a variety of menstrual cycle disorders that are prevalent in athletic women (Warren, 2007:1393). Although the true incidence of menstrual cycle alterations associated with chronic exercise are not fully understood or known, the causes are mainly thought to be multifactorial, including rapid loss in bodyweight (Warren, 2007:1393), sudden onset of strenuous training (Redman & Loucks, 2005:748; Birch, 2005:244), inadequate nutrition to meet energy requirements (Manore, 2002:888; Birch, 2005:244), and psychological and/or physical stress (Warren & Perlroth, 2001:5; Birch, 2005:244).

It has been reported that amenorrhoea occurs in 3,4% to 66% in the athletic population (Vinci, 1999:17; Hobart & Smucker, 2000:3361; Warren, 2007:1393), compared with 2 – 5% of women in the general population (Vinci, 1999:16-17). The pathophysiology of exercise-associated amenorrhoea is complex, with varied contributions by weight loss, lowered body fat, emotional stress and physical stress (West, 1998:66; Vinci, 1999:16-17). It has been reported that athletes who begin training at an early age (prior to the age that normal menarche starts – 12 to 16 years of age), have a higher incidence of amenorrhoea than those who begin training after menarche (Loucks, 2003:144; Redman & Loucks 2005:747). Loucks (2003:144) also found that athletes with amenorrhoea also train at high intensities. There is also a higher level of stress with training in athletes with amenorrhoea than in healthy athletes (Drinkwater *et al.*, 2000:2).

Strenuous exercise may affect the female reproductive system and can lead to athletic amenorrhoea (Redman & Loucks, 2005:747; Birch, 2005:244). The prevalence of menstrual dysfunction in runners ranges from 6% – 43%, depending on the definition of the menstrual problem (Warren & Perlroth, 2001:5; Manore, 2002:888). In a study of female athletes, the incidence of menstrual dysfunction was 7% and appears to be more frequent in athletes who weighed less and were slightly younger (Warren, 2007:1393).

Warren (2007:1393) has shown that amenorrhoea is directly related to weekly training mileage and it could therefore be assumed that long distance female athletes would have the highest incidence of this problem. Studies on English runners spanning similar broad ranges of gynaecological age indicated that the incidence of amenorrhoea rose from 2% to 31% (Rosetta *et al.*, 1998:348; Burrows *et al.*, 2003:68) as training mileage increased from 48 to 68 km/week. Among United States collegiate runners, the incidence of amenorrhoea ranged from <16 to >113 km/week, while bodyweight decreased from >60 to <50kg (Sanborn *et al.*, 1982:859-860). In young competitive long distance female athletes who train 18 hours/week, the incidence of amenorrhoea was 65% (Dusek, 2001:79-80). The concern for the female endurance runner is the alterations in menstrual cycle regularity often reported in those with high training volumes and/or intensities (>20 to 30 km/week and the concomitant effects on health (Burrows & Bird, 2000:33),

probably because both are related to dietary restricting and low body weight. This shows that if athletes train harder, there is a higher incidence of amenorrhoea.

Clark (2002:7) reveals that although amenorrhoea is not sport-specific, sports with the highest prevalence of amenorrhoea include ballet (19 – 44%) and competitive running (24 – 26%), probably because the sport requires a lean body weight. Clark also indicates that a female athlete is more likely to become amenorrhoeic if she has a restrictive diet, low body weight or body fat percentage, has lost weight quickly, exercises vigorously or had an irregular menstrual period before starting a demanding exercise training programme (Clark, 2002:7). It is also suggested that the psychological stress related to heavy exercise training and competition is the cause for menstrual irregularities. Redman and Loucks (2005:750-751), however, found no differences in psychological tests or mood scores between amenorrhoeic and other athletes.

2.3.2 Exercise and body composition

Body composition and weight are two of the many factors that contribute to optimal exercise performance. Taken together, these two factors may affect an athlete's potential for success within a given sport. Body weight can influence an athlete's speed, endurance and power, whereas body composition can affect an athlete's strength, agility and appearance (Heyward & Wagner, 2004:710).

In many sports, body composition is important for optimal physical performance (Heyward & Wagner, 2004:710). In distance running for instance, a lean body appearance is emphasised as beneficial for performance (Greydanus & Patel, 2002:555). It is therefore not unusual for female athletes wanting to lose an extra 2,5 to 5 kg of weight although their weight is often normal or below normal by all medical standards (Manore, 2002:889). Depending on the sport, the impetus for this weight loss is the belief that a lower bodyweight will improve exercise performance. In addition, a smaller body size is easier to move through space and may reduce the risk of injury in high-impact sports (Manore, 2002:889–890).

Stokic *et al.* (2005:195) report that reduced body fat and weight loss are accompanied by later appearance of menstrual cycle disorders. It has been recognised that the critical amount of body fat leading to amenorrhoea is below 17%, while 22% is needed for regular menstrual cycles (Stokic *et al.*, 2005:195; Warren, 2007:1393), and that secondary amenorrhoea can occur when the body fat falls below a critical threshold of 22% of bodyweight (Warren, 2007:1393). Athletes have lower values of body fat mass than sedentary individuals. Body fatness values for most female athletes range from 12 to 16%, depending on the sport (Stokic *et al.*, 2005:195).

2.3.3 Exercise and disordered eating

In recent years, an increasing number of children and pre-adolescents have become concerned about their weight, leading to the development of eating disturbances (Halvarsson *et al.*, 2002:284). Halvarsson *et al.* (2002:284) have observed a marked increase in dieting and the desire to be thinner among 9-14 year-old girls. Other researchers (Rolland *et al.*, 1997:274; De Oliveira *et al.*, 2003:357) report that around 40% of girls between 8 and 13 years of age have actively tried to lose weight. De Oliveira *et al.* (2003:357) found that the weight concerns and dissatisfaction of themselves reported by girls in middle-childhood showed consistency over time. A meta-analysis of eating problems and athletic participation confirmed that athletes are more likely to experience disordered eating and that athletes participating at the elite level in so-called lean sports are particularly at risk (Smolak *et al.*, 2000:371; De Oliveira *et al.*, 2003:357).

Disordered eating seems to be common among female endurance athletes; where between 15 and 62% of female athletes were involved with bodyweight-control behaviours (De Oliveira *et al.*, 2003:357). Disordered eating behaviours (anorexia/bulimia nervosa) can be unhealthy and expose the female athlete to serious health problems, performance impairment and injury (Burrows & Bird, 2000:23-25; De Oliveira *et al.*, 2003:357). As the body initially adapts to the nutritional deficiencies, a decrease in performance may not be detected for some time, thus creating a misconception among athletes that disordered eating practices are harmless. However, food restriction and purging can result not only in menstrual dysfunction and potentially irreversible bone loss, but

psychological and medical complications as well, including depression, fluid/electrolyte imbalances and changes in endocrine/thermoregulatory systems (Burrows & Bird, 2000:23-25; De Oliveira *et al.*, 2003:358). A variety of other factors, such as environment, mood and performance pressures, may contribute to the development of disordered eating patterns in the female athlete (Burrows & Bird, 2000:23-25; De Oliveira *et al.*, 2003:357).

Compulsive exercise, defined as excessive exercise in addition to normal training regimens, is regarded as a form of “purging” or energy expenditure and is often overlooked in athletes (American Academy of Pediatrics, 2000:610; De Oliveira *et al.*, 2003:357). One of the most common behaviours exhibited by sick athletes is inadequate energy intake (calories) for energy expended, resulting in an energy deficit (Papanek, 2003:595; Ronco, 2007:22). Occasionally, this is done unintentionally as training levels increase, but often this behaviour is used as a method to lose weight. Such patterns of disordered eating and compulsive exercise may impair athletic and work performance and can even increase the risk of injury (Putukian, 1998:677; West, 1998:65; De Oliveira *et al.*, 2003:358; Ronco, 2007:22). According to West (1998:65), athletes who decrease their caloric intake, decrease their endurance, strength, reaction time, speed and their ability to concentrate. It can also result in menstrual dysfunction, irreversible bone loss and serious psychological and medical complications (Putukian, 1998:677; American Academy of Pediatrics, 2000:610). These complications can be potentially fatal as a death rate as high as 18% in non-athletes treated for disordered eating's has been reported (Beals *et al.*, 1999:338; Sundgot-Borgen & Torstveit, 2003:48).

2.4 CONCLUSION

The female triad is a unique phenomenon that does not occur overnight but rather appears to gradually infiltrate the adolescent female athlete's lifestyle. Under pressure from parents, coaches, team-mates and themselves, many young women begin to fall into patterns of disordered eating and/or over-intense caloric expenditure without the support of adequate rest and nutrition. The triad is especially troubling due to the fact that, while each affliction can occur independently, each portion is often interrelated by a chain reaction. Amenorrhoea is likely to follow the caloric imbalance, which can lead to osteoporosis. This can result in termination of an athletic career as well as a chronically unhealthy adult life.

The potential factors accountable for menstrual irregularities in female athletes includes the intensity of exercise and low energy consumption, specific type and amount of training, early age initiation, previous menstrual dysfunction, low body mass index (BMI) or percentage body fat, pathological eating habits, and psychological stress.

It could be difficult to identify the female triad syndrome. When confronted by family, friends, coaches and physicians about their eating behaviour, athletes can be anywhere from elusive in their explanation to convinced that nothing is wrong. Although it is more common to find this syndrome affecting female athletes, it is certainly not exclusive to this population. In general, women struggle with the perception of the "perfect body image" society has unfairly placed upon them. Regardless of the circumstances, we as health-care providers, coaches and parents are ultimately responsible for protecting the wellness of the young women in our care. Therefore, we must provide a proper wellness environment by nurturing sound physical training and nutritional habits.

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Chapter 3

Body composition, disordered eating and menstrual dysfunction in young female athletes

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Summary

Aim: The purpose of this study was to determine if there is a relationship between body composition, disordered eating and menstrual dysfunction in young female athletes.

Subjects and methods: Forty-six Caucasian female athletes aged 14 – 25 years, $53, 75 \pm 8.55\text{kg}$ and $164, 85 \pm 7.93\text{cm}$ were recruited and further subdivided into three groups based on their level of performance. They completed a self-administered questionnaire on their menstrual status and history as well as the Eating Disorder Inventory (EDI) and Eating Attitude Test (EAT 26) questionnaires. Body composition was measured by air displacement plethysmography (BOD POD).

Results: The inter-high athletes had a younger chronological age and age of menarche (chronological age = 15, 23 yr; menarcheal age = 12, 95 yr) compared to the provincial (chronological age = 17, 29; menarcheal age = 14, 00 yr) and national (chronological age = 17, 20; menarcheal age = 14, 33 yr) athletes. Six of the total group of athletes have not yet reached menarche and two reached menarche at age 17. Some 21, 74% of the total group has suffered from secondary amenorrhoea and 8, 70% from oligomenorrhoea. Additionally, 10, 7% used oral contraceptives to regulate their menstrual cycles. The inter-high athletes had a practically significant higher body fat percentage level than the provincial athletes ($20, 44 \pm 4, 18$ vs. $16, 29 \pm 4, 57\%$, $d \geq 0, 8$). No differences were found between groups in terms of fat-free mass. There was a low risk for disordered eating amongst all the athletes. However, 22% reported being terrified of being overweight, 19% reported to have vomited before, and 31% used diet pills and laxatives to control their weight.

Conclusion: It can be concluded that menstrual dysfunction is present in this group of young female athletes and that some show signs of extreme weight-control behaviour, although they do not seem to be at risk for an eating disorder. There were no practically significant associations between fat-free mass, disordered eating and menstrual function.

Key words: Female triad, amenorrhoea, eating disorders, adolescent, athletes, endurance athletes, exercise, BMI, body composition, anthropometry, BOD POD, menarche.

3.1 INTRODUCTION

Individual sports have gained in popularity among women, which has led to a greater interest in specific nutritional needs of female athletes (Hassapidou & Manstrantoni, 2001:391). Although exercise is associated with numerous health-related benefits such as weight management, recent research suggests that it can also be linked to dysfunctional attitudes and behaviours (Lane *et al.*, 2004:244). An obsessive attitude toward diet and exercise could be associated with bingeing on food and then engaging in vigorous exercise as a strategy to rid the body of extra energy (Lane *et al.*, 2004:245). Sexual maturation and maintenance of regular menstrual cycles are closely linked to nutritional status (energy availability) and body weight (Foster & Nagatani, 1999:205; Manore, 2002:887; Birch, 2005:245). In the athletic world, young female athletes appear to be most at risk for developing disordered eating patterns than their non-athletic peers, as they are driven by a need to excel in their chosen sport and maintain a lean athletic image in order to excel (Hobart & Smucker, 2000:3357, Sundgot-Borgen & Torstveit, 2004:25). The developing of disordered eating patterns in young female athletes may lead to menstrual dysfunction and subsequent premature osteoporosis (Otis & Goldingay, 2000; Cobb *et al.*, 2003:711; Barr & Rideout 2004:696; Birch, 2005:244). The combination of these three disorders is known as *the female athlete triad*. The triad is a unique phenomenon that does not occur overnight but rather appears to gradually infiltrate female adolescents' life-style. Under intense pressure from parents, coaches, team-mates and often themselves, many young women fall into patterns of disordered eating and/or increased energy expenditure without the support of adequate rest and nutrition (Loucks & Nattiv, 2005:549). The triad is especially troubling due to the fact that while each disorder can occur independently, they are often interrelated by a chain reaction. Menstrual dysfunction is likely to follow a negative energy balance, both of which could lead to osteopenia and increased fracture risk, ultimately resulting in premature osteoporosis (Barr & Rideout, 2004:697; Loucks & Nattiv, 2005:549). This downward spiral can result in the termination of an athletic career as well as a chronically unhealthy adult life.

Menarche, the first occurrence of menstruation, is a landmark in the sexual maturation process of adolescent girls. The age of menarche provides a good indicator of sexual maturation, which can be used as a biological milestone in analysis of growth and performance (Claessens *et al.*, 2003:148). Several studies have established that in general, menarche occurs later in athletes compared to non-athletes, and that the degree of delay is associated with the level of competition, i.e. the higher the level, the later the age of menarche (Geithner *et al.*, 1998:415; Vadocz *et al.*, 2002:93; Claessens *et al.*, 2003:149). The average female undergoes menarche at age 12 to 13; while menarche may be delayed until age 15 in elite athletes. Delayed menarche (primary amenorrhoea) refers to absence of menstrual cycle before the age of 14 years in the absence of secondary sexual characteristics, or by 15 years with normal growth and secondary sexual characteristics (American Society of Reproductive Medicine Practice Committee, 2004:266). Secondary amenorrhoea refers to the cessation of menstruation (between 3-6 consecutive months) after regular cycles have occurred (Hobart & Smucker, 2000:3368; Warren & Goodman, 2003:873). Body fat levels may play an important role in the onset of menarche as well as the maintenance of normal menses. Studies of West (1998:63) and Manore (2002:887) hypothesise that the onset of menarche occurs when a girl achieves a body fat of 17% of her body weight. Body fat percentage has also been linked to a disruption of normal menses after menarche has been reached. Secondary amenorrhoea has been documented to occur when body fat levels fall below 22% (West, 1998:63; Manore, 2002:888). Other forms of menstrual dysfunction in athletes include oligomenorrhoea (≤ 6 cycles/yr), anovulation (bleeding but no ovulation occurs), and luteal phase deficiency (ovulation occurs but there is inadequate progesterone to support endometrial development) (Chen & Brzyski, 1999:4). Irregular menses and anovulation more frequently occur in athletes (up to 60%) compared with non-athletes (approximately 5%) (Hobart & Smucker, 2000:3356; De Souza & Williams, 2004:2; Warren, 2007:1393), with the percentage of those affected being sport-dependent. Irregular menses are reported in up to 20% of casual runners and 50% of elite runners (Greydanus & Patel, 2002:553; Sundgot-Borgen & Torstveit, 2002:118).

The female athlete that is driven to excel in her sport or are pressured to have a thin physique may attempt to lose body weight or body fat by developing patterns of disordered eating (DE), increased energy expenditure, and decreased energy intake (Dueck *et al.*, 1996:95; West, 1998:63; Cobb *et al.*, 2003:711). Energy restriction is common in sport, and for many athletes it is necessary to achieve the sport-specific body weight and composition that result in optimum performance. Because of the importance of fat loss, female athletes in many sports consume 30% less energy per unit of bodyweight than male athletes (Loucks & Nattiv, 2005:549). More recently, secondary amenorrhoea is thought to be rather a consequence of decreased energy availability (higher energy need than intake) than a low proportion of body fat (Loucks & Nattiv, 2005:549). Athletes who increase their training volume, intensity and/or duration without adjusting their energy intake accordingly has an increased risk to have a low energy availability (Loucks & Nattiv, 2005:549). Daily energy balance has been shown to occur in young adults at an energy availability of $\pm 190\text{kJ/kg}$ fat-free mass (FFM) while disrupted menstrual function is associated with an energy availability of $< 125\text{kJ/kg}$ FFM (Loucks & Thuma, 2003:299). Menstrual function is, however, restored with increased energy intake (Dueck *et al.*, 1996:94; Foster & Nagatani, 1999:205; Drinkwater *et al.*, 2000:2).

The effect of disordered eating on an athlete's performance vary, but largely depend on the severity and period of disordered eating behaviour as well as the physiologic demands of the sport (Beals & Meyer, 2007:75; Sundgot-Borgen & Torstveit, 2007:69). An athlete who engages in severe energy restriction or who has been bingeing and purging for a long time is likely to experience a greater decrease in performance than one who has engaged in milder weight control behaviour for a shorter time. Additionally, if athletes that present with prolonged periods of dieting and frequent weight fluctuation have a sudden increase in training volume or a traumatic life event, it could trigger the development of an eating disorder (Beals & Meyer, 2007:75; Sundgot-Borgen & Torstveit, 2007:69). According to Beals and Meyer (2007:75) and Sundgot-Borgen and Torstveit (2007:69-70), athletes involved in endurance sports and other physical activities with high energy demands (e.g., distance running, cycling) are likely to

be more negatively affected than athletes involved in sports with lower energy demands (e.g., diving, gymnastics).

The purpose of this study was to determine if there is a relationship between body compositions (specifically fat-free mass), disordered eating and menstrual dysfunction among a group of 14 – 25 year-old South African female athletes in the North-West Province.

It is hypothesised that athletes with low energy availability will have less fat-free mass due to gluconeogenesis. We therefore propose fat-free mass as an alternative body composition marker to identify those female athletes with an increased risk for disordered eating and menstrual dysfunction.

3.2 METHODS

3.2.1 Subjects

The study involved 46 Caucasian female long-distance athletes ranging in age from 14 – 25 years from five different secondary schools in the North-West Province, and athletes from the North-West University. Athletes were recruited on the basis of availability and classified according to level of performance: Inter-high ($n = 22$), provincial ($n = 14$) and national ($n = 10$) levels. The study was approved by the Ethics Committee of the North-West University (project number: 06M17). All subjects were fully informed of the objectives and testing procedures via verbal and written medium prior to their inclusion and participation in the study. Written informed consent was obtained from participants or from a parent/guardian in the case of minors before they were included in the study. Participants were additionally given written and verbal assurance of anonymity.

3.2.2 Anthropometrics measurements

Body weight and stature were measured to the nearest 0, 1 kg and 0, 1 cm respectively, with the athletes wearing light clothes and no shoes. Body mass index (BMI) was calculated with the formula: $BMI = \text{body weight} / \text{stature}^2$ (kg/m²), and evaluated according to the WHO classification system (1997:8).

3.2.3 Body composition assessment

Body composition including percentage body fat measured by air displacement plethysmography (ADP), using the BOD POD (model 2000A, Life Measurement Instrument, Concord, CA, USA), which has been proven to be an accurate method for assessing body composition (Biaggi *et al.*, 1999:898). For this study only percentage body fat, fat mass and fat-free mass were assessed.

Two measurements were performed on each subject, with subjects wearing tight-fitting underwear, or a swimsuit. A single ADP procedure consisted of two measurements of body volume. If these two measurement differed by more than 150 ml, a third measurement was performed.

Percentage body fat was then calculated from body density (BD) according to the equation of Siri: $\% \text{ body fat} = (4,95 / BD - 4,5) \times 100$.

3.2.4 Menstrual status

A self-administered questionnaire was used to obtain information regarding menstrual status and history. The questionnaire was tested for face validity. Athletes were asked about regularity and duration of menstrual cycles, history of menstrual dysfunction, hormonal therapy use, previous pregnancy, age of menarche, and whether they experienced any changes in their menstrual cycles during the athletic season. The questionnaire was also approved by a medical doctor to ensure that all relevant questions were asked.

3.2.5 Eating patterns and attitude

Participants completed a standardised questionnaire, the Eating Attitude Test-26 (EAT-26; Garner *et al.*, 1982:871), which can be used as a screening tool for people with a high risk for disordered eating. The EAT-26 is composed of 26 items, which are scored on a 6-Point Likert-type scale ranging from always (1), to never (6).

Three subscales constitute the EAT-26: Factor I, Dieting, contains 13 items related to avoidance of fattening foods and pre-occupation with being thinner; Factor II, Bulimia and Food Preoccupation, includes six items that reflect thoughts about food and bulimic behaviour; and Factor III, Oral Control, comprising seven items related to self-control and eating and the perceived pressure from others to increase body weight. A score greater than 20 is considered to be an indicator of a possible disordered eating problem, and individuals who score 20 or more should seek a follow-up evaluation by a qualified professional. Following the 26-items, four behavioural questions are included to determine the presence of extreme weight-control behaviour over the past 6 months. This in conjunction with the EAT-26 score and BMI should be used to identify those with a high risk for a disorder eating or disordered eating patterns.

Participants also completed the Eating Disorder Inventory (EDI; Garner *et al.*, 1983:16). The EDI is a self-reported measure designed to assess attitudes, feelings and behaviour typically associated with eating disorders. The questionnaire was designed to measure psychological and behavioural traits that are common in anorexia nervosa and bulimia nervosa. The instrument consists of 64 items rated on a 6-point Likert-type scale, and subdivided into eight subscales. Three of the subscales measure central eating disorder symptoms: drive for thinness; bulimia; and body dissatisfaction. The additional five subscales measure psychological correlates associated with eating disorders: ineffectiveness; perfectionism; interpersonal distrust; interoceptive awareness; and maturity fears.

The response for each item is given a score from 0 to 3, with a score of 3 assigned to the response farthest in the symptomatic direction, a score of 2 for the immediately

CHAPTER 3

adjacent response, a score of 1 for the next adjacent response, and a score of 0 for the three responses farthest in the asymptomatic direction.

3.2.6 Statistical analysis

Statistical analysis was carried out, using the STATISTICA data analysis software system version 7.1 of the Statistical Consultation Services of the North-West University. Non-parametric statistics were performed due to the small sample size and since subjects were recruited on the basis of availability. Descriptive statistics (mean $\pm$ SD) of all variables for the total group of female athletes ($n = 46$) were obtained and the three different groups were compared, using ANOVA and two-way frequency tables. Due to the non-parametric statistics and small sample size, the practical significance was calculated. A moderate practical significance was determined with $d \geq 0.5$ and a large practical significance with a $d \geq 0.8$.

3.3 RESULTS

3.3.1 Anthropometric measurements

In Table 3.1 characteristics and anthropometric measurements of the three groups are given. There were no practically significant differences between the groups in terms of height, weight, BMI, and fat-free mass. The inter-high group had a practically significantly higher percentage body fat than the provincial group (20, 44% vs. 16, 29%; $d \geq 0.8$).

Table 3.1: Anthropometric measurements of female athletes

Characteristic	Inter-high ($n = 22$)		Provincial ($n = 14$)		National ($n = 10$)	
	Mean	SD*	Mean	SD*	Mean	SD*
Age (yr)	15.23	2.29	17.29	4.10	17.20	3.08
Weight (kg)	54.65	6.39	50.58	10.7	56.21	8.94
Height (cm)	164.5	5.91	163.57	10.37	167.4	8.21
BMI (kg/m^2)	20.18	2.03	18.66	2.25	19.92	1.66
Body fat (%)	20.44 ^a	4.18	16.29 ^b	4.57	18.29	5.98
Fat-free mass	43.52	5.88	42.33	8.87	45.94	7.72

*SD = standard deviation; n = total of athletes; the variable indicated by ^a differs significantly from the variable indicated by ^b ($d \geq 0.8$)

One of the athletes in the provincial group had a BMI of 14.4 kg/m² and eleven (23, 91%) of the athletes (4 = inter-high; 6 = provincial; 1 = national) had a BMI of lower than 18, 5 kg/m², which classified them as being underweight. Four (8,7%) of the athletes, two competing at national level and two competing at provincial level, had a body fat percentage of lower than 11%, which classes them at a health risk. Thirty-three (71, 74%) of the total group of athletes had a percentage body fat of below average (11 – 22%) (adapted from the International Standards for Anthropometric Assessment protocol, 2001), of these, 17 were inter-high athletes, 11 were provincial athletes and 5 were national athletes

3.3.2 Menstrual status

At the time of the survey, 6 athletes had not yet reached menarche, three of whom were 13 years old (inter-high athletes), two were 14 years old (provincial athletes), and one 15 years old (inter-high athlete). Additionally, two national athletes only reached menarche at age 17. The chronological and menarcheal ages for the three different groups are presented in Table 3.2.

Table 3.2: Chronological and age of menarche of the three groups

Characteristic	Inter-high (n = 22)	Provincial (n = 14)	National (n = 10)	Practical significance
Chronological age (yr)	15.23 ± 2.29 ^a	17.29 ± 4.10 ^b	17.20 ± 3.08 ^b	d ≥ 0.5
Menarcheal age (yr)	12.95 ± 1.19 ^a	14.00 ± 1.26 ^b	14.33 ± 1.66 ^b	d ≥ 0.8

Where ^a differ practically significantly from ^b

d ≥ 0.5 = moderate difference; d ≥ 0.8 large difference; n = total of athletes

Inter-high athletes reached menarche 1, 45 years earlier (d ≥ 0.8) than both the provincial and national athletes did.

Table 3.3: Menstrual regularity of the total group and individual groups of athletes

Variable	Total Group (n = 46) % (n)	Inter-high (n = 22) n	Provincial (n = 14) n	National (n = 10) n	Practically significant
Oral contraceptive use	10.87% (5)	1	3	1	$d \geq 0.2$
Somewhat irregular	39.13% (18)	11	5	2	$d \geq 0.2$
Very irregular	26.09% (12)	5	3	4	$d \geq 0.2$
Changes in cycle during season	30.43% (14)	6	3	5	$d \geq 0.2$
Changes in cycle with increased exercise volume/intensity	23.91% (11)	4	2	5	$d \geq 0.2$
Primary amenorrhoea	2.17% (1)	1	0	0	$d \geq 0.2$
Secondary amenorrhoea	21.74% (10)	7	2	1	$d \geq 0.2$
Oligomenorrhoea	8.70% (4)	3	1	0	$d \geq 0.2$
Missed at least one cycle	60.90% (28)	15	6	7	$d \geq 0.2$

From Table 3.3 it is clear that irregular menstrual cycles are prominent in many of the athletes and some had a history of primary (2,17%) and secondary (21,74%) amenorrhea, as well as oligomenorrhoea (8,70%). There were, however, no practically significant differences between the groups in terms of menstrual regularity.

3.3.3 Eating patterns and attitude

3.3.3.1 EAT-26

None of the athletes scored more than 20 for the EAT-26 questionnaire and there were no practically significant differences between the groups. Athletes scored highest for the dieting subscale, but mean scores were still low (Table 3.4). Weight-control behavioural questions showed that none of the athletes had previously been treated for an eating disorder. Twenty-two per cent (22%) of the athletes, however, reported that they are terrified of being overweight, 28% reported that they have gone on eating binges before, 9% have vomited to control their weight, and 31% reported that they make use of diet pills or laxatives to control their weight. There was no practical significance between the three groups of athletes.

3.3.3.2 Eating Disorder Inventory

There were no practically significant differences between the three groups of athletes for all the subscales of the EDI (Table 3.4), with the exception of the perfectionism subscale. National athletes had a practically significant higher score (7.7 ± 3.86 versus 4.64 ± 3.13 and 4.55 ± 4.59 ; $d \geq 0.8$) than the provincial athletes and the inter-high athletes respectively. All athletes had a high score for body dissatisfaction.

The provincial athletes had the lowest ineffectiveness subscale (1.29 ± 1.97) score compared to the inter-high and national athletes (3.23 ± 3.64 ; 3.2 ± 3.85). This subscale “assesses feelings of general inadequacy, insecurity, worthlessness, emptiness and lack of control over one’s life (Reinking & Alexander, 2005:49). The national athletes (6.9 ± 5.84) had the highest score for the drive for thinness subscale. This subscale assesses “excessive concern with dieting, preoccupation with weight and fear of weight gain”, while the provincial athletes (4.64 ± 5.36) had the lowest score.

Table 3.4: Descriptive statistics for the Eating Disorder Inventory (EDI) and the Eating Attitude Test (EAT - 26) of the three groups of athletes

Characteristic	Inter-high		Provincial		National		Practical Significance
	Mean	SD	Mean	SD	Mean	SD	
EDI Scores							
Drive for thinness subscale (0 - 21)	5.18	5.07	4.64	5.36	6.9	5.84	$d \geq 0.2$
Bulimia subscale (0 - 21)	1.09	1.95	0.5	1.09	2.7	2.87	$d \geq 0.5$
Body dissatisfaction subscale (0 - 27)	10.09	7.35	6.29	8.18	12	9.26	$d \geq 0.5$
Ineffectiveness subscale (0 - 30)	3.23	3.64	1.29	1.97	3.2	3.85	$d \geq 0.5$
Perfectionism subscale (0 - 18)	4.55	4.59	4.64	3.13	7.7	3.86	$d \geq 0.8$
Interpersonal distrust subscale (0 - 21)	3	2.6	3.36	4.13	4.8	4.59	$d \geq 0.2$
Interoceptive awareness subscale (0 - 30)	5.41	5.32	2.14	2.48	3.8	3.16	$d \geq 0.5$
Maturity fears subscale (0 - 24)	4.5	1.97	3.5	1.99	5.2	3.22	$d \geq 0.5$
EAT-26 Scores							
Dieting subscale	5.4	5.9	5.9	7.6	8.3	5.6	$d \geq 0.5$
Bulimia and food preoccupation subscale	2.2	1.7	1.9	1.8	3.4	2.5	$d \geq 0.5$
Oral control subscale	3	3.6	4.3	3.3	2.1	1.6	$d \geq 0.5$

After dividing the total group of athletes into two groups according to a history of secondary amenorrhoea ($n = 10$) and no history of secondary amenorrhoea ($n = 32$), no difference were found in terms of either the EDI or EAT-26 subscale scores.

3.4 DISCUSSION AND CONCLUSION

The results of this study show that there were no practically significant differences between the groups in terms of height, weight, BMI and fat-free mass. The inter-high group had a practically significantly higher percentage of body fat than the provincial group (20, 44% vs. 16, 29%). The results also show that at the time of the survey one athlete presented with primary amenorrhoea and two other had a history of primary amenorrhoea. Additionally, 21, 74% of the athletes had a history of secondary amenorrhoea and 8, 70% a history of oligomenorrhoea. Inter-high athletes reached menarche 1, 45 years earlier than both the provincial and national athletes. None of the athletes could be classified as having an eating disorder/disordered eating, although some showed signs of extreme dieting behaviour.

Although there were no significant differences between the three groups in terms of mean BMI, seven provincial athletes presented with a BMI below 18,5, which classifies them as being underweight. A possible reason for this could be because of physical and mental stress to which these athletes are exposed to (Loucks, 2003:144).

It has been well documented that the prevalence of amenorrhoea and menstrual disorders are common in the athletic population and often greater than in the general female population (Loucks & Nattiv, 2005:550; Stokic *et al.*, 2005:195; Fogelhom & Hiiloskorpi, 1999:230; Skolnick, 1993:923). Skolnick (1993:923) found 3, 4 – 66% of female athletes and 2 – 5% of non-athletic women to suffer with amenorrhoea, while a Finnish study reported menstrual disturbance in 27 – 37% of aesthetic, endurance and weight-bearing athletes but only in 5% of controls (Fogelhom & Hiiloskorpi, 1999:231). This study also found a prevalence of menstrual disturbances. Some 26% of our athletes considered themselves to have very irregular (more than 10 days variation) cycles, 21,74% of the athletes reported a history of secondary amenorrhoea, and 8,70% a history of oligomenorrhoea.

A number of factors have been suggested to contribute to the development of athletic menstrual dysfunction, namely energy balance, disordered eating behaviour, exercise intensity and training practices, bodyweight and body composition, and physical and emotional stress (Sundgot-Borgen & Torstveit, 2007:69).

It has been reported that reduced body fat, a low BMI and weight loss contribute to a later appearance of menarche, menstrual cycle disorders and problems with conception, related to the reduction of sex-specific body fat involved in functioning of the reproductive system (Claessens *et al.*, 2003:148; Stokic *et al.*, 2005:196). In this study, however, athletes with a low BMI and percentage body fat did not show any signs of menstrual dysfunction. On the other hand, even though inter-high athletes had normal BMIs and percentage body fat levels, they reported the highest history of secondary amenorrhoea. Therefore, BMI and percentage body fat does not seem to be related to the present or history of menstrual disturbances or amenorrhoea in this group of athletes. Other possible reasons could include exercise intensity, physiological stress and energy availability. This was, however, not measured in the present study. A study done by Stokic and co-workers (2005:196) amongst a group of ballet dancers ($n = 30$) compared to controls ($n = 30$) found that the ballet dancers had a mean BMI of $18,56 \pm 1,53 \text{ kg/m}^2$ and percentage body fat of $18,85 \pm 4,50\%$. Despite these normal values, 20% presented with secondary amenorrhoea and 10% with oligomenorrhoea. These results are similar to those of our study in that BMI and percentage body fat were not reliable predictors of risk for menstrual disorders. Studies also suggested that athletic amenorrhoea can result from hormonal effects such as increased prolactin, endorphins and/or androgens (Eliakim & Beyth, 2003:205; Loucks, 2003:144). It has been claimed that amenorrhoea is caused by the athlete's psychological preoccupation with weight and thinness, which in turn may lead to weight loss, and also to optimise performance (Otis, *et al.*, 1997: iii). None of these possible contributing factors to menstrual irregularities were, however, measured in this study.

Recent findings suggest that low energy availability, rather than low body fatness or exercise stress, is the likely mechanism by which exercise negatively influences the hypothalamo-hypophyso-ovarian axis in female athletes (Warren, *et al.*, 1999:875; Williams, *et al.*, 2001:5187; Loucks, 2003:149; Beals & Meyer, 2007:73).

Energy availability has been defined as the amount of dietary energy remaining for all other physiologic functions after energy has been expended in exercise (Beals & Meyer, 2007:73). Low energy availability results from consuming less energy than is necessary to cover the additional energy demands of exercise, which is seen more and more in sports that emphasise a lean physique or a low body weight (e.g., long-distance runners)(Beals & Meyer, 2007:73). The energy-drain and exercise-intensity hypotheses suggest that athletic amenorrhoea or other reproductive hormone abnormalities observed in female athletes may be partly due to periods of energy deficiency, or a combination of high energy expenditure, low energy intake and/or high psychological and physical stress (Manore, 2002:889; Sundgot-Borgen & Torstveit, 2007:70). Studies done by Loucks and colleagues (2003:298; 2005:551) where they tested this energy balance hypothesis in sedentary and exercising women have found supporting results. According to Manore, (2002:889) the most common nutritional issues in athletes with disordered eating and/or menstrual dysfunction are poor energy consumption and/or poor food selections. If energy drain is the primary contributing factor to athletic menstrual dysfunction, better balance will improve overall nutritional status and may reverse menstrual dysfunction, thus returning the athlete to normal reproductive status.

It is well documented that athletes reach menarche at a later age than non-athletes (Dusek, 2001:79; Stokic *et al.*, 2005:196). Torstveit and Sundgot-Borgen (2005:141) examined the prevalence of menstrual dysfunction in the total population of Norwegian elite female athletes ($n = 669$) and a control group ($n = 607$) and found that the age of menarche was significantly later in the athletes than the controls ($13, 4 \pm 1, 4$ versus $13, 0 \pm 1, 3$ yrs, $p < 0.0001$). This study shows that inter-high athletes reached menarche at a significantly earlier age than athletes competing at national and provincial level. Possible reasons for this late onset of menarche may include the level of physical and mental

stress to which national athletes are exposed to (Sambanis *et al.*, 2003:398; Fujii & Demura, 2003:97; Loucks, 2003:144).

Female athletes are at a high risk for eating disorders (ED) and disordered eating (DE) (Byrne & McLean, 2001:145; Cobb *et al.*, 2003:711; Sundgot-Borgen & Torstveit, 2004:25) because of the pressure to achieve the sport-specific bodyweight and composition that result in optimum performance. A study done by Johnson *et al.* (1999:179) investigated the prevalence of DE in female (n = 562) and male (n = 883) athletes and found that 1,1% of the female athletes met the criteria for bulimia nervosa and 2,8% met the criteria for anorexia nervosa, while none of the males met the criteria for bulimia or anorexia nervosa. No eating disorders or disordered eating patterns were, however, found in the present study amongst all athletes and no differences between EDI and EAT-26 subscale scores were found between the different groups. A possible reason for the absence of a difference between the groups could be due to the small sample size. Factors implicated in contributing to the development of DE include social pressure to be thin; chronic dieting; low self-esteem; family dysfunction, physical or sexual abuse; participation in sports that emphasise a low body weight or particular body shape such as long-distance running (Beals, *et al.*, 1999:339). Usually, aesthetic athletes are at a greater risk to develop ED or DE than non-aesthetic athletes (Smolak *et al.*, 2005:373). A study done by Reinking and Alexander (2005:48) amongst a group of athletes (n = 84) and non-athletes (n = 62) found that 7, 1% of the athletes and 12, 9% of the non-athletes were classified as having a high risk for disordered eating. Of these athletes, 2, 9% were athletes from non-lean-sports (basketball, volleyball, soccer, field hockey and softball) and 25% from lean-sports (swimming and cross-country). Sundgot-Borgen and Torstveit (2007:69) also found in their study on the female athlete triad in connection with football players (n = 69), handball players (n = 60) and endurance runners (n = 115) that 44% of the endurance athletes met the criteria for ED compared to 24% of the football players and 29% of the handball players.

Although the athletes in the present study had on average low EDI scores, national athletes showed the highest score for the perfectionism scale compared to the other two groups. Thompson and Sherman, (1999:318) found that a personality trait such as perfectionism has been theorised to be important for successful athletic training and that it could explain why the national athletes had the highest score.

Warren and Perlroth (2001:4) found that disordered eating; particularly energy restriction, causes menstrual abnormality. Disordered eating may impair athletic and work performance and increase the risk of injury. Decreased energy intake with resulting fluid and electrolyte imbalances can result in decreased endurance, strength, reaction time, speed and ability to concentrate (West, 1998:64). Food restriction and purging can also result in menstrual dysfunction, irreversible bone loss and serious psychological and medical complications (West, 1998:64). A study done by Cobb and associates (2003:711) amongst competitive female distance runners ($n = 91$) found that of the 23 of the athletes that had elevated EDI scores 65% presented with oligoamenorrhoea, compared to only 25% of athletes ($n = 67$) with normal EDI scores. They also found that the drive for thinness EDI subscale had the strongest association with oligoamenorrhoea. De Souza and associates (2007:359) also found in their study of 43 exercising women that chronic energy deficiency is related to menstrual disturbances. Our study found no relationship between ED/DE and menstrual dysfunction. It could be because our sample size was too small, not randomised, or possibly too few real elite competitors were recruited due to the area where recruitment took place. However, high scores were not expected in this study group, since athletes were from a non-lean sporting type. A study done by Wade *et al.* (2006:121) among female twins ($n = 1002$) also found no association between ED/DE and menstrual dysfunction or frequency of amenorrhoea ($p = 0.89$).

Female athletes who experience menstrual dysfunction, particularly amenorrhoea, often show little concern for the disruption in their cycles; some even express relief at the “break” (Beals & Meyer, 2007:70). Similarly, some coaches simply dismiss menstrual dysfunction, believing it is a natural result of hard training. Nonetheless, despite these attitudes, it should be emphasised that menstrual dysfunction is not a normal response to

training; rather it is a clear indication that health is being compromised (Beals & Meyer, 2007:70; Nattiv *et al.*, 2007:1867).

Although none of the athletes in the current study had menstrual dysfunctions or were at risk for ED/DE, there was a history of menstrual irregularities as well as many who presented with extreme dieting behaviour. These facts can be seen as early warning signs for developing the clinical manifestations of the female athlete triad, namely eating disorders, functional hypothalamic amenorrhoea, and osteoporosis (Nattiv *et al.*, 2007:1867). Additionally, each individual component of the triad (i.e., energy availability, menstrual function and bone mineral density), is known to have various health consequences and should therefore be prevented or treated as effectively as possible. Pre-season screening of female athletes for the triad and/or its components is therefore recommended to improve early prevention and/or treatment. Additionally, the results obtained in the present study should prompt athletes, their coaches and parents to learn about the possible physiological changes and risk factors that might accompany intensive sports training.

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CHAPTER 3

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CHAPTER 3

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Chapter 4

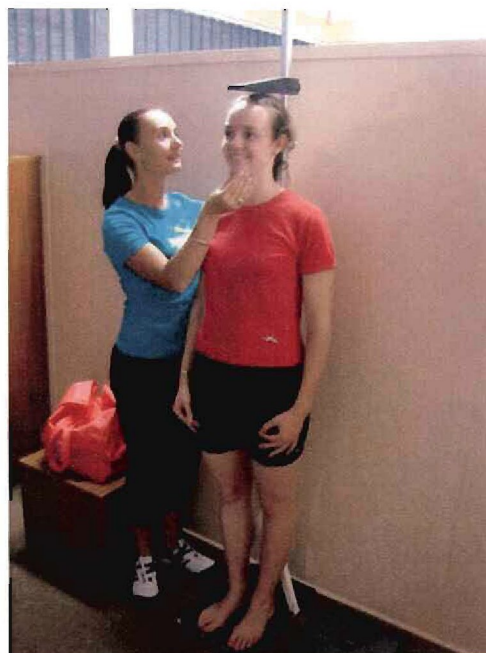
Training volume and menstrual dysfunction in young female athletes

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Summary

Aim: To determine the relationship between training volume and menstrual dysfunction in young female athletes.

Subject and methods: Forty-six Caucasian long-distance athletes between the ages of 14 and 25 years completed self-administered questionnaires on their training volume, menstrual status and the Exercise Dependence Questionnaire.

Results: The average weight, height and BMI for this group of athletes were 53, 75 ± 8 , 55 kg, 164, 85 ± 7 , 93 cm, and 19, 66 ± 2 , 09 (kg/m^2). Six of the total group of athletes have not yet reached menarche, while two reached menarche at the age of 17. Some 21 (74%) of the total group have suffered from secondary amenorrhoea and 8 (70%) from oligomenorrhoea. Some 30 (43%) reported that they experience changes in their menstrual cycles during their training season, and 23 (91%) reported a change in their menstrual cycle with an increase in their exercise volume.

The national athletes reported more training sessions per week (6–7 times a week), and their training sessions (1–2,5 hours) were longer when compared with the inter-high (5 times a week); (1 hour) and provincial (6 times a week); (1–1,5 hours) athletes. They also reported the highest number of stress fractures (30%) compared to the inter-high (4, 55%) and the provincial (21, 43%) athletes.

None of the athletes presented with primary or secondary amenorrhoea, irrespective of their training hours per day or training days per week.

Conclusion: No relationship was found between menstrual dysfunction and training volume in the group of athletes that was studied.

Key words: Female triad, amenorrhoea, eating disorders, adolescent, athletes, endurance athletes, exercise, BMI, body composition, anthropometry, BOD POD, menarche, training volume.

4.1 INTRODUCTION

The popularity of competitive sports and the number of women taking part in sports and top-level competitions have increased substantially in recent times (Donaldson, 2003:323; Castelo-Branco *et al.*, 2006:32). This is accompanied by constantly increasing levels of competition and more demanding physical training. Exercise has many beneficial effects on mental and physical activity; however, excessive training may lead to health problems in the long term, including a wide spectrum of menstrual dysfunctions (Warren, 1999:1893; Dusek, 2001:80; Sambanis *et al.*, 2003:399). It has been suggested that if exercise becomes excessive, serious detrimental physical and psychological consequences may accrue, e.g. anaemia, depressed immune response, menstrual irregularity, anxiety and depression (Hausenblas & Downs, 2002a:90; Hausenblas & Downs, 2002b:388; Edmunds, 2006:888). High-intensity training, specific types of training and the amount of training, reduced body weight, lower percentage of fat tissue, and psychological stress, have been put forward as potential factors responsible for menstrual irregularities in female athletes (Dusek, 2001:80).

Numerous studies have established that, in general, menarche occurs later in athletes compared with non-athletes, and that the degree of delay is associated with the level of competition, for example the higher the level, the later the age of menarche (Beunen & Malina, 1996:4; Geithner *et al.*, 1998:415; Vadocz *et al.*, 2002:93). Menstrual dysfunction is more prevalent among female athletes than it is among non-athletes (Warren & Shantha, 2000:37; Thompson, 2007:129) and is especially common among women who participate in sports where a thin build may improve performance (Warren & Shantha, 2000:38; Thompson, 2007:129). Athletes who appear to be at the greatest risk for developing menstrual dysfunction usually begin training prior to menarche, have an extremely intense training regimen, consume few kilojoules of energy and have a low body weight (Thompson, 2007:129-130). Although Malina (1998:133 & 2000:95) claims that training is a causal factor in delay of age of menarche in athletes, hard evidence to support this is still lacking.

According to J. Harlan (2006), a prominent women's college cross-country coach for 11 years, stated that female college cross-country runners typically run between 48 and 113 km per week and many do not consume enough kilojoules to replace what they burn in their workouts. A study of 30 female distance runners reported that 93% of the athletes under-consume kilojoules of energy, 60% experienced menstrual irregularities, and 60% suffered from low-spinal bone loss (Fredirecson, *et al.*, 2003:32). Low bone mass puts athletes at an increased risk for stress fractures and also future osteoporosis (Fredirecson, *et al.*, 2003:32).

Reports on the incidence of menstrual dysfunction in athletes vary widely, with studies confirming earlier observation of higher incidences of menstrual dysfunction in aesthetic, endurance and weight-class sports at younger ages of participation (Burrows & Bird, 2003:281), higher training volumes (Burrows & Bird, 2003:281) and lower bodyweight (Burrows & Bird, 2003:281). In two studies of English runners spanning similarly broad ranges of gynaecological age, the incidence of menstrual dysfunction rose from 2% to 31% (Rosetta *et al.*, 1998:345; Burrows & Bird, 2003:281-282) as training kilometers increased from 48 to 68 km/week. Among United States college runners, the training volume ranged from < 16 to >113 km/week and bodyweight decreased from > 60 to < 50 kg (Burrows & Bird, 2003:282). In young competitive long-distance runners training 18 hours/week the incidence of menstrual dysfunction was 65% (Dusek, 2001:79).

According to Dusek (2001:80), more than 8 hours of vigorous exercise a week may cause amenorrhoea. Although physical exercise has many benefits, too much exercise can negatively affect the female athlete, causing amenorrhoea, one of the components of the female athlete triad (which refers to disordered eating, menstrual dysfunction, and osteopenia) (Thompson, 2007:129). When athletes restrict their food intake and train hard, hormonal changes can affect the reproductive system and cause menstrual dysfunction (Thompson, 2007:129).

The purpose of this research article was to determine if there is a relationship between training volume and menstrual dysfunction among a group of 14–25 year-old South African female athletes in the North-West Province.

4.2 METHODS

4.2.1 Subjects

The study involved 46 Caucasian female long-distance athletes ranging in age from 14–25 years from five different secondary schools in the North-West Province and athletes from the North-West University. Athletes were recruited on the basis of availability and classified according to level of performance: Inter-high ($n = 22$), provincial ($n = 14$) and national ($n = 10$) levels. The study was approved by the Ethics Committee of the North-West University (project number: 06M17). All subjects were fully informed of the objectives and testing procedures via verbal and written medium prior to their inclusion and participation in the study. Written informed consent was obtained from participants or from a parent/guardian in the case of minors before they were included in the study. Participants were additionally given written and verbal assurance of anonymity.

4.2.2 Menstrual status

A self-administered questionnaire was used to obtain information regarding menstrual status and history. The questionnaire was tested for face validity. Athletes were asked about regularity and duration of menstrual cycles, history of menstrual dysfunction, hormonal therapy use, previous pregnancy, age of menarche, and whether they experienced any changes in their menstrual cycles during the athletic season. The questionnaire was also approved by a medical doctor to ensure that all relevant questions were asked.

4.2.3 Training volume data

All the athletes completed a self-administered questionnaire on training volume. Athletes were asked to recall how many days per week they train, how many training sessions they had per day and how long each session was. They were also asked if they would like to increase their training time. Athletes were asked to recall if they had ever suffered a stress fracture or soft-tissue injury due to training, and if training ever had an influence on their menstrual cycles.

4.2.4 Statistical analysis

Statistical analysis was carried out, using the STATISTICA data analysis software system version 7.1 of the Statistical Consultation Services of the North-West University. Non-parametric statistics were obtained due to the small sample size and since subjects were recruited on the basis of availability. Descriptive statistics (mean $\pm$ SD) of all variables for the total group of female athletes ($n = 46$) were obtained and the three different groups were compared, using ANOVA and two-way frequency tables. Due to the non-parametric statistics and small sample size, the practical significance was calculated. A moderate practical significance was determined with $d \geq 0.5$ and a large practical significance with a $d \geq 0.8$.

4.3 RESULTS

4.3.1 Menstrual status

At the time of the survey, 6 athletes had not yet reached menarche, three of whom were 13 years old (inter-high athletes), two were 14 years old (provincial athletes), and one was 15 years old (inter-high athlete). Additionally, two national athletes only reached menarche at age 17. The chronological and menarcheal ages for the three different groups are presented in Table 4.1.

CHAPTER 4

Table 4.1: Chronological and age of menarche of the three groups

Characteristic	Inter-high (n = 22)	Provincial (n = 14)	National (n = 10)	Practical significance
Chronological age (yr)	15.23 ± 2.29 ^a	17.29 ± 4.10 ^b	17.20 ± 3.08 ^b	d ≥ 0.5
Menarcheal age (yr)	12.95 ± 1.19 ^a	14.00 ± 1.26 ^b	14.33 ± 1.66 ^b	d ≥ 0.8

Where ^a differ practically significantly from ^b
d ≥ 0.5 = moderate difference; d ≥ 0.8 large difference

Inter-high athletes reached menarche 1, 45 years earlier (d ≥ 0.8) than both the provincial and national athletes did.

Table 4.2: Menstrual regularity of the total group and individual groups of athletes

Variable	Total Group (n = 46) % (n)	Inter-high (n = 22) n	Provincial (n = 14) n	National (n = 10) n	Practical significant
Oral contraceptive use	10.87% (5)	1	3	1	d ≥ 0.2
Somewhat irregular	39.13% (18)	11	5	2	d ≥ 0.2
Very irregular	26.09% (12)	5	3	4	d ≥ 0.2
Changes in cycle during season	30.43% (14)	6	3	5	d ≥ 0.2
Changes in cycle with increased exercise volume/intensity	23.91% (11)	4	2	5	d ≥ 0.2
Primary amenorrhoea	2.17 % (1)	1	0	0	d ≥ 0.2
History of secondary amenorrhoea	21.74% (10)	7	2	1	d ≥ 0.2
Oligomenorrhoea	8.70% (4)	3	1	0	d ≥ 0.2
Missed at least one cycle	60.90% (28)	15	6	7	d ≥ 0.2

From Table 4.2 it is clear that irregular menstrual cycles are prominent in many of the athletes, while some had a history of primary (2,17 %) and secondary (21,74 %) amenorrhoea, as well as oligomenorrhoea (8,70 %). There were, however, no practically significant differences between the groups in terms of menstrual regularity. In addition, 30, 43 % of the athletes reported that they experienced a change in their menstrual cycle during their training season, while 24% reported a change in their menstrual cycle with an increase in their training volume. No practically significant differences were found between the three groups of athletes.

4.3.2 Training volume

Most inter-high athletes had the highest frequency of training session per week. They trained five times a week, while the provincial and national athletes trained mostly six times a week. From Figure 4.1 it can also be seen that many of the national athletes trained seven times a week. There were moderate practically significant differences ($d \geq 0.5$) between the national athletes' training sessions per week and the inter-high and provincial athletes' training sessions per week.

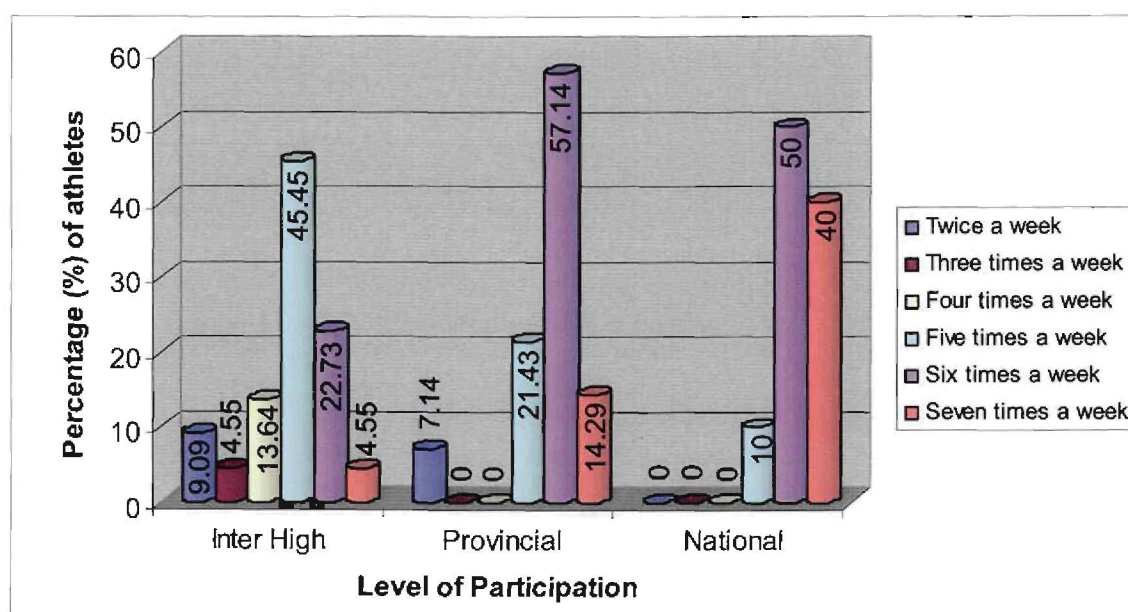


Figure 4.1: Frequency of training sessions per week

Most athletes had only one training session per day, while some of the national athletes (20%) reported three training sessions per day. There were no practically significant differences between the three groups regarding their frequency of training sessions per day.

The results for the different durations of training outlined in Table 4.3 revealed that provincial athletes did not train for more than 1-1½ hours, where the national athletes varied between an 1-2½ hours per training session. There were moderate practically significant differences ($d \geq 0.5$) between the three groups regarding their training hours per day.

Table 4.3: Length of training sessions

	High-School n = 22	Provincial n = 14	National n = 10
Length of training sessions			
One hour (1)	50.00% (11)	50.00% (7)	10.00% (1)
One to one and a half hour (1 - 1½)	31.82% (7)	50.00% (7)	30.00% (3)
One and a half to two hours (1½ - 2)	09.09% (2)	00.00% (0)	00.00% (0)
Two hours (2)	00.00% (0)	00.00% (0)	10.00% (1)
Two to two and a half hours (2 - 2½)	09.09% (2)	00.00% (0)	50.00% (5)

Since there were no large practically significant differences between the three groups of athletes regarding their training sessions per week, training session per day or the length of their training sessions, it was no surprise to find no practically significant differences between the three groups regarding the prevalence of stress fractures and soft-tissue injuries. There is, however, a tendency that the national athletes have more training sessions per week and their training sessions are longer compared with the inter-high and provincial athletes, and therefore a tendency of stress fractures. A possible reason for no practically significant differences found between the three groups of athletes could be because the sample size was too small.

To evaluate the influence of training volume on amenorrhoea, the athletes were re-divided into three groups regarding their menstrual cycle (regular, somewhat irregular, and very irregular).

At the time of the survey, six athletes had not yet reached menarche. Ten (22%) of the athletes reported that their menstrual cycles were regular (inter-high = 4; provincial = 3; national = 3), eighteen (39%) of the athletes considered their menstrual cycles to be somewhat irregular (inter-high = 11; provincial = 5; national = 2) and twelve (26%) of the athletes reported their cycles to be very irregular (inter-high = 5; provincial = 3; national = 4).

Table 4.4: Athletes' training sessions per week

	Regular (n = 10)	Somewhat irregular (n = 18)	Very irregular (n = 12)	Practical significant
Training sessions per week				
Twice a week	00.00% (0)	11.11% (2)	08.33% (1)	$d \geq 0.2$
Three times a week	00.00% (0)	05.56% (1)	00.00% (0)	$d \geq 0.2$
Four times a week	00.00% (0)	05.56% (1)	16.67% (2)	$d \geq 0.2$
Five times a week	20.00% (2)	27.78% (5)	25.00% (3)	$d \geq 0.2$
Six times a week	60.00% (6)	33.33% (6)	41.67% (5)	$d \geq 0.2$
Seven times a week	20.00% (2)	16.67% (3)	08.33% (1)	$d \geq 0.2$

Five (41,67%) of the athletes who reported that their menstrual cycle were very irregular exercised six times a week, compared to six of the (33,33%) athletes who reported their cycles to be somewhat irregular and six (60%) of the athletes whose cycles were regular, as seen in Table 4.4. Only one (8, 33%) athlete who exercised seven times a week reported her cycle to be very irregular. There were no practically significant differences between the three groups of athletes regarding their training sessions per week.

Table 4.5: Athletes' training sessions per day

	Regular (n = 10)	Somewhat irregular (n = 18)	Very irregular (n = 12)	Practical significant
Training sessions per day				
One session per day	80.00% (8)	83.33% (15)	66.67% (8)	$d \geq 0.2$
Two sessions per day	20.00% (2)	05.56% (1)	25.00% (3)	$d \geq 0.2$
Three sessions per day	00.00% (0)	11.11% (2)	08.33% (1)	$d \geq 0.2$

Three athletes whose menstrual cycles were very irregular trained twice a day, and only one athlete whose cycle was very irregular had three training sessions a day (Table 4.5), compared to one athlete whose cycle was somewhat irregular and who trained twice a day and the two athletes with somewhat irregular cycles who trained three times a day. None of the athletes whose menstrual cycles were regular trained three times a week. There were no practically significant differences between the three groups of athletes regarding their training sessions per day.

Table 4.6: Length of training sessions

	Regular (n = 10)	Somewhat irregular (n = 18)	Very irregular (n = 12)	Practical significant
Length of training sessions				
One hour (1)	30.00% (3)	50.00% (9)	25.00% (3)	$d \geq 0.5$
One to one and a half hour (1 - 1½)	40.00% (4)	33.33% (6)	41.67% (5)	$d \geq 0.5$
One and a half to two hours (1½ - 2)	00.00% (0)	11.11% (2)	00.00% (0)	$d \geq 0.5$
Two hours (2)	10.00% (1)	00.00% (0)	00.00% (0)	$d \geq 0.5$
Two to two and a half hour (2 - 2½)	20.00% (2)	05.56% (1)	33.33% (4)	$d \geq 0.5$

Four athletes (33, 33%) who reported that their cycles were very irregular trained for 2-2½ hours a day (Table 4.6), compared to the two (20%) athletes whose cycles were regular and the one (5, 56%) athlete whose cycle was somewhat irregular. There were only a moderate ($d \geq 0.5$) practically significant difference compared to the three groups' length of training sessions. The above tables show that although the athletes reported that their menstrual cycles were very irregular, they did not train more or longer than the other two groups of athletes.

The athletes were again divided into a group that has gone for three months or more without a menstrual cycle, that is with a history of secondary amenorrhoea. Ten of the athletes reported that they had gone for more than three months without a menstrual cycle (7 = inter-high; 2 = provincial; 1 = national).

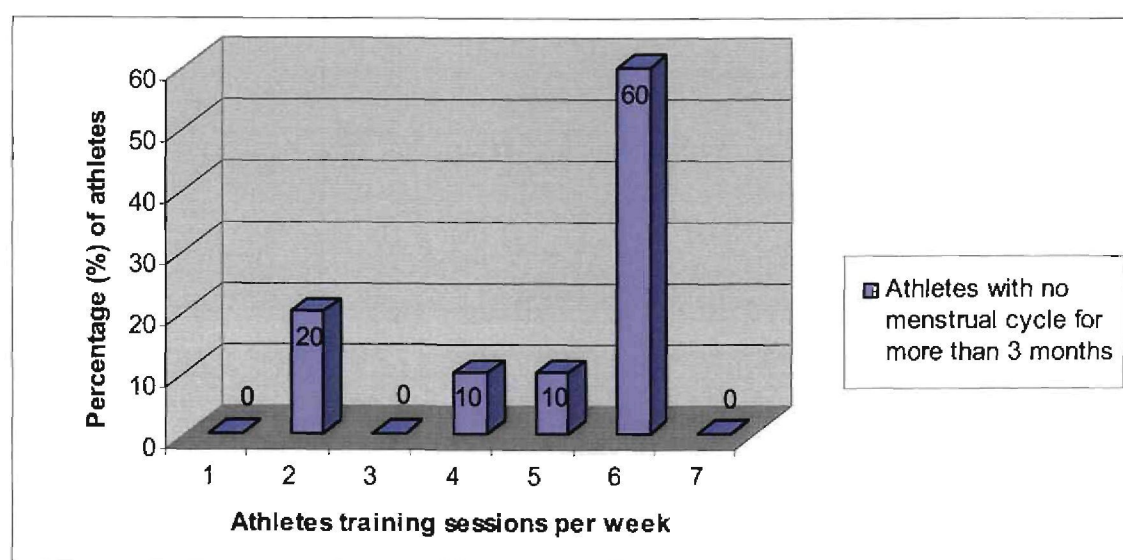


Figure 4.2: Athletes' training sessions per week

Six (60%) of the ten athletes who had gone for three months without a menstrual cycle reported that they exercised six times a week (Figure 4.2). Figure 4.3 shows that seven of the athletes only trained once a week and none of them exercised for more than two sessions a day. There were no practically significant difference between the athletes and their training sessions per day or per week.

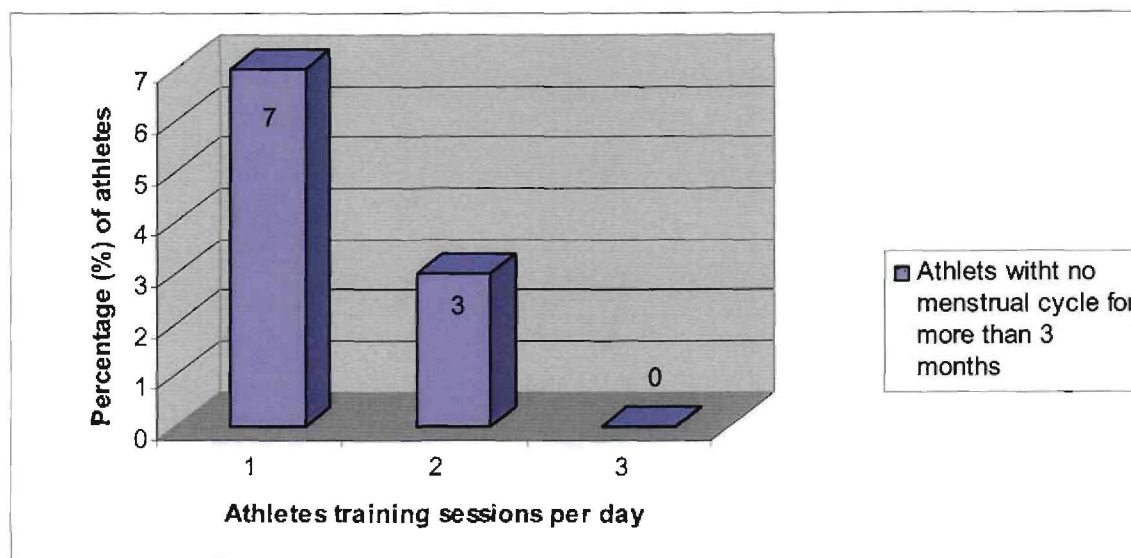


Figure 4.3: Athletes' training sessions per day

Of the ten athletes only 2 athletes trained for 2-2½ hours a day, three athletes trained for 1-1½ hour, while the remaining five reported that they train only for one hour a day. No practically significant differences were reported.

Even though the athletes reported that they had gone without a menstrual cycle for three months (history of secondary amenorrhoea), they did not exercise longer or more than the other athletes did.



4.4 DISCUSSION AND CONCLUSION

The results show that there were no large practically significant differences between the groups in terms of their training sessions per week, their training sessions per day or the length of their training sessions. The national athletes showed a moderate practically significant difference regarding their training sessions per week (6 times vs. 5 times) and length of their training sessions (1-2½ hours vs. 1-1½ hour). The results also show that at the time of the survey, one athlete presented with primary amenorrhoea and two other had a history of primary amenorrhoea. Additionally, 21 (74%) of the athletes presented with a history of secondary amenorrhoea and 8 (70%) with a history of oligomenorrhoea. The inter-high athletes reached menarche 1, 45 years earlier than both the provincial and national athletes did.

The prevalence of amenorrhoea and menstrual disorders are more common in the athletic population than in the general female population (Loucks & Nattiv, 2005:549; Stokic *et al.*, 2005:195; Skolnick, 1993:921). A study done by Skolnick (1993:921) found that 3,4 – 66% of female athletes and 2–5% of non-athletic women suffer from amenorrhoea, while a Finnish study done by Loucks & Nattiv (2005:549) reported menstrual disturbance in 27–37% of aesthetic, endurance and weight-bearing athletes but in only 5% of controls. This study also found a prevalence of menstrual disturbances. Some 26% of our athletes considered themselves to have very irregular (more than 10 days variation) cycles, 21,74% of the athletes reported a history of secondary amenorrhoea, and 8,70% a history of oligomenorrhoea.

Dusek (2001:80) and Stokic *et al.* (2005:196) have documented that athletes reach menarche at a later age than non-athletes do. A study done by Torstveit and Sundgot-Borgen (2005:141) examined the prevalence of menstrual dysfunction in the total population of Norwegian elite female athletes (n = 669) and a control group (n = 607) and found that the age of menarche was significantly later in the athletes than in the controls (13, 4 ± 1, 4 versus 13, 0 ± 1, 3 yrs, p <0.0001). This study shows that inter-high athletes reached menarche at a significantly earlier age than athletes competing at

national and provincial level. A possible reasons for this late onset of menarche in our national athletes could be the increased training session per week, the long training hours as well as the physical and mental stress to which these athletes are exposed (Sambanis *et al.*, 2003:399; Fujii & Demura, 2003:98; Loucks, 2003:146) to keep a thin body appearance and to achieve optimum results like national colours.

Energy balance, disordered eating behaviours, exercise intensity and training practices, bodyweight and body composition, and physical and emotional stress, are a number of factors that have been suggested to contribute to the development of athletic menstrual dysfunction (Sundgot-Borgen & Torstveit, 2007:69). In Chapter 3 we looked at the influence of bodyweight, body composition and disordered eating behaviours on the menstrual cycle, and in this chapter we examine exercise intensity and training practices.

The effects of intense physical exercise on the menstrual cycle are a delay in menarche, luteal-phase defects (oligomenorrhoea and other menstrual dysfunctions) and anovulations (Torstveit & Sundgot-Borgen, 2005:143; Castelo-Branco *et al.*, 2006:33). A study done by Castelo-Branco and associates (2006:31) among a group of ballet dancers ($n = 38$) and controls ($n = 77$) found that the dancers had a higher prevalence of oligomenorrhoea and amenorrhoea than control girls ($p = 0.004$). Dusek (2001:79), who did a study on the influence of intensive training on menstrual cycles in active female athletes ($n = 72$) and controls ($n = 96$) also found that the prevalence of secondary amenorrhoea was three times higher in athletes than in the control group. It has often been demonstrated that athletes competing at a higher level show menstrual dysfunction compared with athletes classified at a lower competitive level (Dusek, 2001:79; Torstveit & Sundgot-Borgen, 2005:141; Castelo-Branco *et al.*, 2006:31). This observation is, however, not supported by our data, as no significant differences in menstrual dysfunction between the inter-high, provincial or national athletes were found. The most obvious explanation for this would be that the sample size was too small and that the study did not involve the most competitive school in the North-West Province. A study done by Claessens and associates (2003:148) among a group of female junior rowers ($n =$

212) also found no evidence to state that intensive rowing training has a negative influence on their menstrual cycle.

In conclusion, the results from our study show that there were no relationship between training volume and menstrual dysfunction. However, it is still not clear whether athletes have menstrual dysfunction because of genetic factors, high training volume or the possibility that their body type allows them to excel at sports and therefore would experience late menarche whether or not they were participating in sport. More research is needed to answer these questions. The results obtained in this study and in others should prompt female athletes, their coaches and parents to learn about the changes that might accompany intensive sports training. Long-lasting secondary amenorrhoea increases the risk of stress fractures at a younger age and osteoporosis in adult years. Amenorrhoea, low body weight and osteoporosis, the so-called female athlete triad, should be the focus of research, for its prevention, early recognition and treatment are mandatory in order to reduce health risks.

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Journal of clinical endocrinology and metabolism, 84:1892-1896.

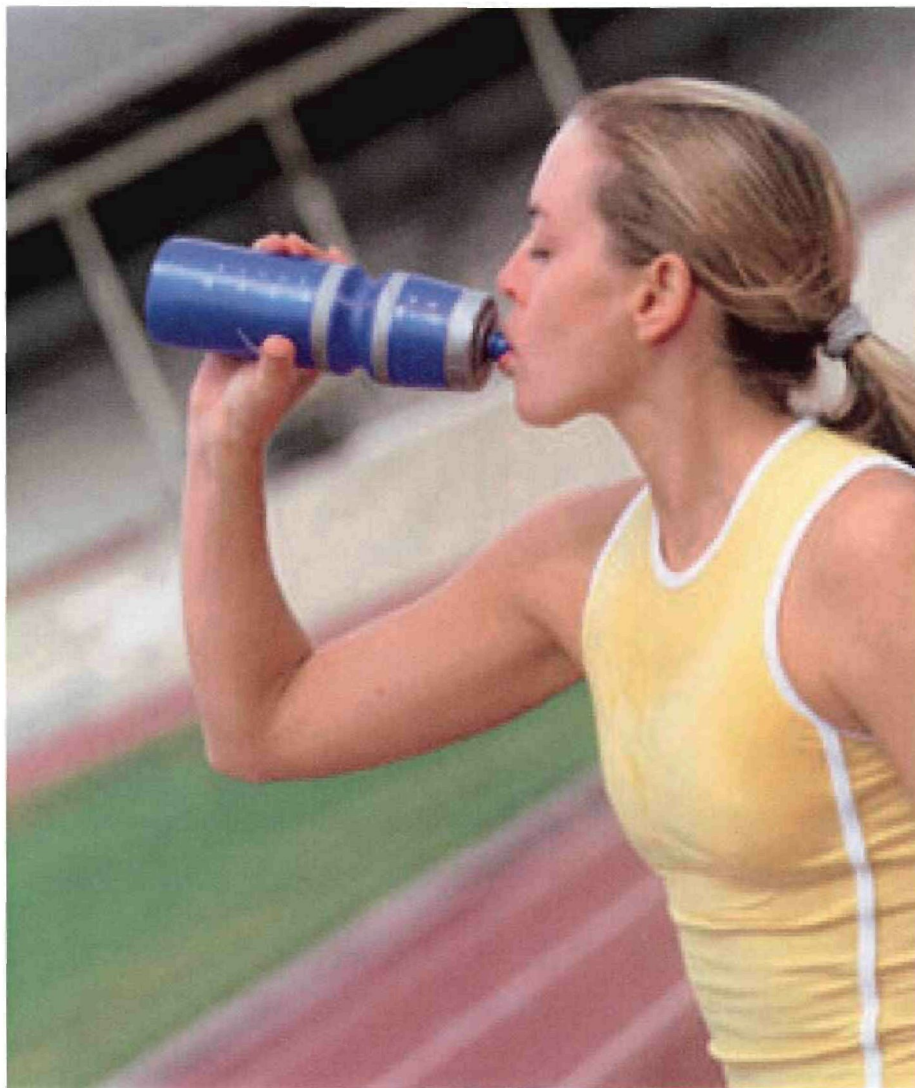
WARREN, M.P. & SHANTHA, S. (2000).

The female athlete.

Baillieres clinical endocrinology and metabolism, 14:37-53.

Chapter 5

Summary, Conclusions and Recommendations



5

Summary, Conclusion and Recommendations

5.1 SUMMARY

5.2 CONCLUSION

5.3 RECOMMENDATIONS

5.1 SUMMARY

The aim of this study was firstly to determine by means of the body mass index (BMI), percentage body fat, a self-administered menstrual dysfunction questionnaire and the EAT-26 and EDI questionnaire whether there is a relationship between body composition, disordered eating and menstrual dysfunction in 14 – 25 year-old female athletes. The second aim was to determine whether there is a relationship between training volume and menstrual dysfunction in 14 – 25 year-old female athletes. Chapter 1 provided a brief introduction and outline of the problem statement that underlines the research questions, aims and hypotheses that form the basis of this study.

This dissertation is submitted in article format, as approved by the Senate of the North-West University and therefore includes one review article (Chapter 2) and two research articles (chapters 3 and 4 respectively). Chapter 2 is a literature review in the form of a review article on amenorrhoea, percentage body fat, training volume and disordered eating by Botha, T., de Ridder, J.H., Malan, D.D.J. and Wright, H.H. The chapter firstly introduced the reader to the literature format of this article by means of an introduction. The introduction was followed by a section explaining the female athlete triad and its components. This was followed by the influence of exercise on the female triad and the causes of amenorrhoea. The chapter was concluded by focusing on the identification and prevention of the female athlete triad.

The first research article entitled *Body composition, disordered eating and menstrual dysfunction in young female athletes* by Botha, T., de Ridder, J.H., Malan, D.D.J. and Wright, H.H. is included in Chapter 3. The main purpose of this article was to determine by means of body composition and questionnaires whether there is a relationship between body composition, disordered eating and menstrual dysfunction among a group of 14 – 25 year-old South African female athletes in the North-West Province.

The second article, entitled *Training volume and menstrual dysfunction in young female athletes* by Botha, T., de Ridder, J.H., Malan, D.D.J. and Wright, H.H. is included in Chapter 4. The aim of this article was to determine by means of questionnaires if there is a relationship between training volume and menstrual dysfunction among a group of 14 – 25 year-old South African female athletes in the North-West Province.

All the above-mentioned articles were written according to the guidelines of the specific journals (see attachment A) and consist of an introduction, problem statement and the resulting research questions and purposes of the study. The research methods (subjects, measurement procedures and statistical analysis) were described, after which the results were presented and discussed. Each article concluded with research conclusions and implications.

5.2 Conclusion

The conclusions that are drawn from this research are presented in accordance with the set hypotheses (see Chapter 1).

5.2.1 Hypothesis 1: *There is a positive relationship between body composition and menstrual dysfunction in 14 – 25 year-old female athletes.*

The inter-high athletes showed a practically significant higher percentage body fat than the provincial athletes, while the inter-high athletes reached the age of menarche practically significantly earlier than both the provincial and national athletes do.

However, no relationship between BMI, percentage body fat and menstrual dysfunction could be found and therefore hypothesis 1 is rejected.

5.2.2 Hypothesis 2: *There is a positive relationship between disordered eating and menstrual dysfunction in 14 – 25 year-old female athletes.*

Hypothesis 2 is rejected based on the research findings that there were no practically significant differences between disordered eating and menstrual dysfunction. Although the athletes did show signs of extreme weight-control behaviours, they did not seem to be at risk for an eating disorder or showed signs of any previous eating disorders or menstrual dysfunction and therefore no relationship could be found.

5.2.3 Hypothesis 3: *The training volume of the female athlete plays a significant role in the prevalence of menstrual dysfunction.*

Hypothesis 3 is also rejected based on the research findings that there were also no practically significant differences found. None of the athletes' training sessions per week, frequency of training sessions per day or length of training sessions played a role in their menstrual dysfunction. Although some athletes did report a change in their menstrual cycle during the training season and with an increase in their training volume, no relationship could be found.

5.3 Recommendations

The results of this study emphasise the importance of further research regarding the possible reasons for menstrual dysfunction in 14 – 25 year-old female athletes, as there is clearly a shortage of literature that focuses on this research theme (long-distance athletes) and within this age group.

Additional studies are needed to better determine how training volume, hormone replacement therapy, body fat and disordered eating influence menstrual irregularities and the health of competitive female runners. Athletes should receive nutritional education and be informed of the risk of the female athlete triad.

Increase awareness and educational efforts among health professionals, coaches, trainers, athletic department directors, health educators, parents and physicians are needed to insure optimal physical and mental health among athletes.

Certain shortcomings regarding this study can, however be indicated:

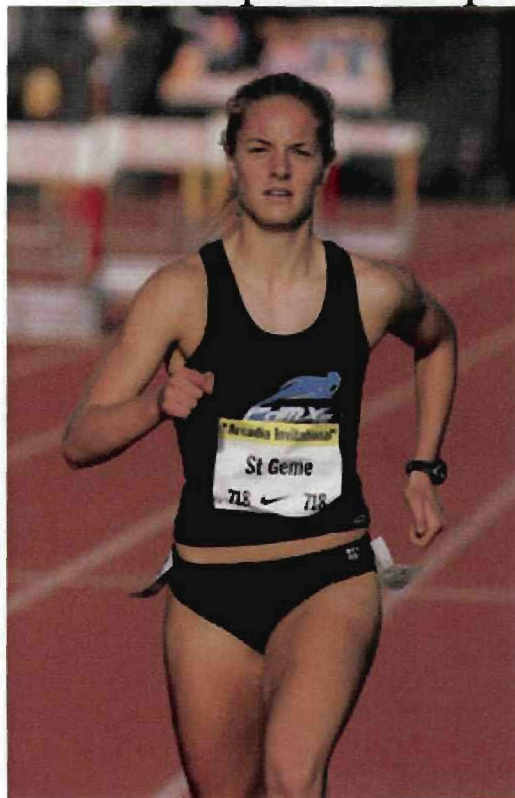
- Subjects were recruited according to availability; therefore not the most competitive athletes were used in the study.
- The study consisted of a small number of subjects and did not involve the most competitive school in the North-West Province.
- The study only involved students from the North-West Province.
- The sample size was definitely too small.
- Although the survey was anonymous, the athletes were not totally honest when completing the questionnaires, as they could have thought that their coaches or family would have insight into their information.
- Because the athletes were still very young, it could be that they did not understand the questionnaires correctly or were too scared to ask.

5.4 Future research

If this study were to be repeated, this researcher would make the sample size much bigger and not limit it to a specific area. Athletes should be chosen according to their performance level and because they are the best in that specific item that they are competing in and not because of availability. It should also be ensured that the athletes understand the complications of the female athlete triad and how it could affect their future. It seemed as if most of the athletes were only interested in their appearance. The athletes should also understand the questionnaires. For that reason it could be better to use older and more mature athletes. Some of the athletes did not take the questionnaires seriously. Future research should also focus on bone density and the effect that menstrual dysfunction has on it.

Appendices

- Appendix A Guidelines for Authors
- Appendix B Ingeligte toestemmingsvorm
Informed consent
- Appendix C Questionnaires
- Appendix D Anthropometric performance



Appendix A

Guidelines for Authors

- Journal of Human Movement Studies



The “Journal of Human movement studies”

CORRESPONDENCE

All correspondence should be sent to address given below. Please provide your fax number and, for preference, communicate messages (but not manuscript) by fax with back-up letter by post. Please ensure envelopes are well secured when sending manuscript by post. Please quote your Journal Reference Number in all further correspondence (e.g. JHMS 559 etc).

PRODUCTION METHODS

All Teviot Scientific Publications are now produced, whenever possible, from authors computer disks. Please send one original plus two copies of the typed manuscript using standard fonts. Please avoid block capitals, bold and underlined and follow the style of the Journals in details.

TEXT

Please use Microsoft Word 2000 or later.

FIGURES AND TABLES

Figures should be submitted on disk in the original graphics programme and also in the text.



SUBMISSION OF PAPERS

The purpose of the Journal is to serve as a forum for original papers and research reports which contribute to the understanding of human movement. Areas of enquiry may extend across topics as diverse as movement in communication, aesthetic evaluation of human movement, comparative studies in movement, etc. Animal studies are only acceptable if they have implications for the study of human movement.

PRESENTATION GUIDELINES

Papers should be submitted in good English. The order of presentation of original manuscripts is as follows: title, summary page, introduction methods, results, discussion, tables/figures/photographs and references. The summary should be approximately 200 words and the pages should be numbered consecutively. Reviews should be accompanied by a summary.

The title page should be laid out as follows: title of the paper, names of authors (without qualifications or title), institutions and full address for correspondence. Authors should provide a fax and telephone numbers as well as e-mail addresses where available.

References should appear in the format of the examples given below:

KENNEDY, M.D.J. AND BELL, C.J. (1996).

Measurement of heart rate response during a 55km cross country ski race.

Journal of Human Movement Studies, 31: 161-177.

APPENDICES

KELSO, J.A.S. AND DING, M. (1993).

Fluctuations, intermittency and controllable chaos in biological co-ordination.

In Variability and motor control.

Human Kinetics, (Edited by K.M. Newell and D.M. Corcos), Champaign, IL., pp.
291-316.

Appendix B

Ingeligte toestemmingsvorm

Informed consent



Ingeligte toestemmingsvorm

Geagte Atleet

NAVORSINGSTUDIE – VOORKOMS VAN AMENORREE, VERSTEURDE EETPATRONE, LIGGAAMSAMESTELLING EN OEFENINGSVOLUME BY JONG MIDDEL- EN LANGAFSTAND VROUE-ATLETE

Die voorkoms van amenorree, liggaamsamestelling en versteurde eetpatrone by jong middel- en langafstand vroue-atlete is van belang vir afrigters, dieetkundiges en mediese spesialiste aangesien dit 'n belangrike rol speel by die gesondheid, en daarom ook die toekomstige prestasie van genoemde atlete. Amenorree en versteurde eetpatrone is bekend as voorlopers vir die Female Athlete Triad, wat genoemde twee komponente sowel as osteoporose/osteopenia, insluit. Die doel van hierdie studie is (1) om die voorkoms van amenorree, versteurde eetpatrone en oefeningsvolume by genoemde atlete te bepaal deur middel van 'n vraelys, (2) om die verband tussen persentasie liggaamsvet, amenorree, versteurde eetpatrone en oefeningsvolume te bepaal en (3), om die afrigter te bemaatig om die voorkoms van hierdie toestand te voorkom, atlete wat 'n risiko toon te identifiseer en meer inligting te kry rakende gepaardgaande gesondheidsrisiko's. Hierdie studie word onderneem deur die Skool vir Biokinetika, Reakreasie en Sportwetenskap (BRS) by die Noordwes-Universiteit (Potchefstroom-kampus).

Inligting rakende die studie

1. Die doel van hierdie studie is tweeledig: (1) om die voorkoms van amenorree, versteurde eetpatrone en oefeningsvolume, deur middel van 'n vraelys by jong middle- en langafstandatlete te bepaal, (2) om die verband tussen persentasie liggaamsvet, amenorree, versteurde eetpatrone en oefeningsvolume te bepaal en (3), om die afrigter te bemaatig om die voorkoms van hierdie toestand te voorkom, atlete

APPENDICES

- wat 'n risiko toon te identifiseer en meer inligting te kry rakende gepaardgaande gesondheidsrisiko's.
2. Die voorkoms van amenoree, versteurde eetpatrone en oefeningsvolume sal deur middel van 'n vraelys gemeet word. Elke atleet sal die vraelys individueel in 'n onderhoud voltooi.
 3. Privaatheid en konfidensialiteit is noodsaaklike en die individu sal deur 'n vroulike biokinetikus ondervra word.
 4. Liggaamsmassa en persentasie liggaamsvet gaan gemeet word deur middel van die Bod Pod. Elke atleet sal individueel gemeet word. Die meetprosedure vereis dat die atleet slegs swemklere of 'n sportbra en 'n dylengte ski-broek dra met geen hemp, skoene, kouse of juwele nie. Privaatheid is van kardinale belang en die individu sal deur 'n vroulike biokinetikus gemeet word.
 5. U samewerking en ondersteuning in die verband sal waardeer word.
 6. Vir enige verdere navae, kontak Tershia by 082 575 6042.

By voorbaat dankie

Tershia Botha
(Biokinetikus en M-student)

Prof. J.H de Ridder
(Promoter: Skool vir BRS, NWU)

As the informed consent was handled by means of Afrikaans, a translation follows.

Informed consent

Dear Athlete

RESEARCH STUDY – OCCURRENCE OF AMENORRHOEA, DISTURBED EATING PATTERNS, BODY COMPOSITION AND EXERCISE VOLUME IN YOUNG MIDDLE AND LONG-DISTANCE FEMALE ATHLETES

The occurrence of amenorrhoea, body composition and disturbed eating patterns in young middle and long-distance female athletes are important for trainers, dieticians and medical specialists because these factors play an important role in the health, and therefore the future performance of these athletes. Amenorrhoea and disturbed eating patterns are well known for being precursors of the Female Athlete Triad, which includes the above-mentioned two components as well as osteoporosis/osteopenia. The aim of this study is (1) to determine the occurrence of amenorrhoea, disturbed eating patterns and exercise volume in the above-mentioned athletes by means of a questionnaire, (2) to determine the relationship between percentage body fat, amenorrhoea, disturbed eating patterns and exercise volume and (3), to empower the trainer to prevent the occurrence of this condition, identify athletes that are at risk and to obtain more information with regard to associated health risks. This study is undertaken by the School of Biocinetics, Recreation and Sports Science (BRS) at the North-West University (Potchefstroom Campus).

Information regarding the study

1. The aim of this study is twofold: (1) to determine the occurrence of amenorrhoea, disturbed eating patterns and exercise volume by means of a questionnaire in young middle and long-distance athletes, (2) to determine the relationship between body fat, amenorrhoea, disturbed eating patterns and exercise volume

APPENDICES

and (3), to empower the trainer to prevent the occurrence of this condition, to identify athletes that are at risk and to obtain more information regarding accompanying health risks.

2. The occurrence of amenorrhea, disturbed eating patterns and exercise volume will be measured by means of a questionnaire. Each athlete will complete the questionnaire during an interview.
3. Privacy and confidentiality are crucial and the individual will be interviewed by a female biokineticist.
4. Body mass and percentage body fat will be measured by means of the Bod Pod. Each athlete will be measured individually. The measuring procedure requires that the athlete should wear only a swimsuit or a sports bra and thigh-length ski pants, with no shirt, shoes or jewels. Privacy is crucial and the individual will be measured by a female biocinetitian.
5. Your co-operation in this regard will be appreciated.
6. For any further enquiries, please contact Tershia on 082 575 6042.

Thank you in advance

Tershia Botha
(Biokineticist and Masters student)

Prof. J.H de Ridder
(Promoter: School of BRS, NWU)

APPENDICES

I, the undersigned, (full names)
have read the above information regarding the project and also heard the verbal account thereof and declare that I understand both. I was afforded the opportunity to discuss relevant aspects of the project with the project leader and declare that I am participating willingly in the project. I give my permission to be a participant in this project.

I hereby indemnify the University as well as any employer or student of the University from any accountability that may arise towards me during the course of the project.

I further undertake not bring any claims against the University because of damage or personal loss that I might suffer as a result of the project/test or through the actions of other experimental subjects, unless it is due to the negligence of the University, its employers or students.

(Signature of experimental subject)

Signed at..... on this..... day of

WITNESSES

1.

2.

Signed at..... on thisday of

APPENDICES

For all participants and interventions in participants under the age of 21 years the written consent of the parent or legal guardian is needed.

I (full names) parent or legal guardian hereby give permission that the participant mentioned above may participate in this project and hereby indemnify the University as well as any employer or student of the University from any accountability that might arise towards me during the course of the project unless such injury, loss or death is caused by the negligence of the University, its personnel or students.

Signature: Date:

Relationship:

Appendix C

Questionnaires

- Personal Information
- Menstrual History Questionnaire
- Training Volume Questionnaire
- Exercise Dependence Questionnaire
- Eating Attitudes Test (EAT-26) Questionnaire
- Eating Disorder Inventory (EDI) Questionnaire



Personal Information

Subject Number: _____

1. Birth date (day/month/year) ____/____/____

2. Age (years) _____

3. Ethnicity: **(check one)**

☐ Black

☐ Coloured

☐ White

☐ Other

4. Are you in: **(check one)**

☐ High School

☐ University

☐ Postgraduate

☐ Working

5. Event(s) specialised in: _____

6. Number of years specialising in event(s): _____

7. Highest level (provincial, national, external) reached in event(s): _____



Menstrual History Questionnaire

1. Have you ever had a menstrual period?

☐ Yes

☐ No

2. At what age did you have your first menstrual period? _____

3. When was your last menstrual period? _____

4. How many menstrual periods have you had in the last 12 months? _____

in the last 6 months? _____

5. Please describe the regularity of your cycle? (**check one**)

☐ I am very regular (within 3 days)

☐ I am somewhat irregular (4-10 day variation)

☐ I am very irregular (variation greater than 10 days)

6. Are there changes in your menstrual period during you athletic season?

☐ Yes

☐ No

➤ If **yes**, please describe the changes: _____

7. Do your periods change with changes in you training regimen?

☐ Yes

☐ No

➤ If **yes**, please describe the changes: _____

8. Have you ever missed a menstrual cycle?

☐ Yes

☐ No

➤ If **yes**, please answer the questions below:

8.1 At what age did it occur? _____

APPENDICES

8.2 For how long was it absent? _____

8.3 Had you been exercising intensely at the time?

☐ Yes ☐ No

8.4 Were you using any medication at the time?

☐ Yes ☐ No

9. Have you ever gone for three or more months without having a menstrual period (except during pregnancy)?

☐ Yes ☐ No

➤ If yes, how many times have you gone three or more months without having a period? _____

➤ If yes, how many times have you gone without menstruating?

10. Do you currently take birth-control pills or hormone supplements?

☐ Yes ☐ No

➤ If yes, how long have you been using the medication?

➤ If you answered yes, why are you using them?(**check one**)

☐ Birth control

☐ Regulate menstrual cycle

☐ Both

☐ Other, please specify: _____

11. Have you ever been to a gynaecologist?

☐ Yes ☐ No

➤ If yes, when was the visit and for what reason?

Training Volume Questionnaire

1. How many days per week do you train? **(check one)**

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

2. How many training session do you have per day? **(check one)**

☐ 1 ☐ 2 ☐ ≥ 2

3. How long is a training session on average? _____

4. Would you like to include more hours in your exercise sessions than there are at present?

☐ Yes ☐ No

➤ If yes, how many more? _____

5. What type of exercise do you do, and how many times a week?

☐ Endurance/aerobic: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ ≥ 5

☐ Speed: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ ≥ 5

☐ Technique: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ ≥ 5

☐ Gym: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ ≥ 5

☐ Cross training: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ ≥ 5

☐ Other: _____

6. Is there a history of osteoporosis in your family?

☐ Yes ☐ No

7. Have you ever been diagnosed with a stress fracture as a result of training or competition?

☐ Yes ☐ No

➤ If yes, how many stress fractures have you had and where?

APPENDICES

8. Have you ever suffered a soft-tissue (e.g. muscle, tendon or ligament) injury as a result of training or competition?

☐ Yes

☐ No

- If yes, how many injuries have you had and where?
-



Exercise Dependence Questionnaire

We would like to know how much you exercise. Please consider exercise as being any structured activity that increases your heart rate, e.g. running, cycling, aerobics, weight training. Please complete the following sentence:

I exercise for _____ hours per week.

Below are a series of statements that people have used to describe their attitudes to exercise. Please rate each of the statements by circling the appropriate number for how much it describes your attitude to your own exercise over the past month. Please use the following scale:

Strongly Disagree							Strongly Agree	
1	2	3	4	5	6	7		

1.	My level of exercising makes me tired	1	2	3	4	5	6	7
2.	After an exercise session I feel happier about life	1	2	3	4	5	6	7
3.	If I cannot exercise I feel irritable	1	2	3	4	5	6	7
4.	The rest of my life has to fit in around my exercise	1	2	3	4	5	6	7
5.	After an exercise session I feel less anxious	1	2	3	4	5	6	7
6.	I exercise to look attractive	1	2	3	4	5	6	7
7.	I sometimes miss time at work to exercise	1	2	3	4	5	6	7
8.	After an exercise session I feel that I am a better person	1	2	3	4	5	6	7
9.	If I cannot exercise I feel agitated	1	2	3	4	5	6	7
10.	I exercise to meet other people	1	2	3	4	5	6	7
11.	I hate not being able to exercise	1	2	3	4	5	6	7
12.	I exercise to keep me occupied	1	2	3	4	5	6	7
13.	If I cannot exercise I feel I cannot cope with life	1	2	3	4	5	6	7
14.	I exercise to control my weight	1	2	3	4	5	6	7
15.	I have little energy for my partner, family and friends	1	2	3	4	5	6	7
16.	Being thin is the most important thing in my life	1	2	3	4	5	6	7

APPENDICES

17.	I feel guilty about the amount I exercise	1	2	3	4	5	6	7
18.	I exercise to be healthy	1	2	3	4	5	6	7
19.	After an exercise session I feel thinner	1	2	3	4	5	6	7
20.	My level of exercise has become a problem	1	2	3	4	5	6	7
21.	I make a decision to exercise less but cannot stick to it	1	2	3	4	5	6	7
22.	I exercise for the same amount of time each week	1	2	3	4	5	6	7
23.	After an exercise session I feel more positive about myself	1	2	3	4	5	6	7
24.	My weekly pattern of exercise is repetitive	1	2	3	4	5	6	7
25.	My pattern of exercise interferes with my social life	1	2	3	4	5	6	7
26.	I exercise to feel fit	1	2	3	4	5	6	7
27.	My exercising is ruining my life	1	2	3	4	5	6	7
28.	I exercise to prevent heart disease and other illnesses	1	2	3	4	5	6	7
29.	If I cannot exercise I miss the social life	1	2	3	4	5	6	7



Eating Attitudes Test (EAT-26) Questionnaire

Current Weight: _____ kg

Highest Weight: _____ kg

Lowest Weight: _____ kg

Ideal Weight: _____ kg

Please choose one response by marking a $\sqrt$ for each of the following statements:	Always	Usually	Often	Some times	Rarely	Never	Score
1. I am terrified about being overweight							
2. I avoid eating when I am hungry							
3. I find myself preoccupied with food							
4. I have gone on eating binges where I feel that I may not be able to stop							
5. I cut my food into small pieces							
6. I am aware of the caloric content of foods that I eat							
7. I particularly avoid foods with a high carbohydrate content							
8. I feel that others would prefer if I ate more							
9. I vomit after I have eaten							
10. I feel extremely guilty after eating							
11. I am preoccupied with a desire to be thinner							
12. I think about burning up calories when I exercise							
13. Other people think that I am too thin							
14. I am preoccupied with the thought of having fat on my body							
15. I take longer than others to eat my meals							
16. I avoid food with sugar							
17. I eat diet foods							
18. I feel that food controls my life							
19. I display self-control around food							
20. I feel that others pressure me to eat							
21. I give too much time and thought to food							
22. I feel uncomfortable after eating sweets							
23. I engage in dieting behaviour							
24. I like my stomach to be empty							
25. I have the impulse to vomit after meals							

APPENDICES

26. I enjoy trying rich new foods								
Total Score =								
Behavioural questions:								
In the past 6 months have you:							Yes	No
A. Gone on eating binges where you feel that you may not be able to stop? (Eating much more than most people would eat under the same circumstances). If yes, how often during the worst week: _____								
B. Ever made yourself sick (vomited) to control your weight or shape? If yes, how often during the worst week: _____								
C. Ever used laxatives, diet pills or diuretics (water pills) to control your weight or shape? If yes, how often during the worst week: _____								
D. Ever been treated for an eating disorder? If yes, when: _____								



Eating Disorder Inventory (EDI) Questionnaire

Please choose one response by marking a ✓ for each of the following statements:	1	2	3	4	5	6
	Always	Very often	Often	Sometimes	Rarely	Never
I eat sweets and carbohydrates without feeling guilty						
I get frightened when my feelings are too strong						
I think about dieting						
I get confused about what emotion I am feeling						
I eat when I am upset						
I think that my stomach is too big						
I feel ineffective as a person						
I wish that I could return to the security of childhood						
Only an outstanding performance is good enough in my family						
I am open about my feelings						
I stuff myself with food						
I think that my thighs are too large						
I feel alone in the world						
I wish that I could be younger						
As a child I tried very hard to avoid disappointing my parents						
I trust others						
I feel extremely guilty after over-eating						
I can clearly identify what emotion I'm feeling						
I have gone on eating binges where I have felt that I could not stop						
I think that my stomach is just the right size						
I feel generally in control of things in my life						
The happiest time in life is when you are a child						
I hate being less than the best at things						
I can communicate with others easily						
I am terrified of gaining weight						
I don't know what's going on inside of me						

APPENDICES

I think about overeating						
I feel satisfied with the shape of my body						
I wish I were someone else						
I would rather be an adult than a child						
My parents have expected excellence of me						
I have close relationships						
I exaggerate or magnify the importance of weight						
I get confused as to whether or not I am hungry						
I eat moderately in front of others and stuff myself when I am alone						
I like the shape of my buttocks						
I feel inadequate						
The demands of adulthood are too great						
I feel that I must do things perfectly or not do them at all						
I have trouble expressing my emotions to others						
I am preoccupied with the desire to be thinner						
I worry that my feelings will get out of control						
I have thought of trying to vomit in order to lose weight						
I think my hips are too big						
I feel secure about myself						
I feel that people are happiest when they are children						
I have extremely high goals						
I feel happy that I am not a child anymore						
If I gain a pound (kilogram) I worry that I will keep gaining						
I feel bloated after eating a small meal						
When I am upset I don't know if I am sad, frightened or angry						
I eat or drink in secrecy						
I think my thighs are just the right size						
I have a low opinion of myself						
The best years of your life are when you become an adult						
I feel that I can achieve my standards						

APPENDICES

I need to keep people at a certain distance (feel uncomfortable if someone tries to get too close)						
I think my buttocks are too large						
I feel that I am a worthwhile person						
I have feelings I can't quite identify						
When I am upset I worry that I will start to eat						
I think that my hips are just the right size						
I feel emotionally empty inside						
I can talk about personal thoughts or feelings						



Appendix D

Anthropometric Performance



Anthropometric Performance

Subject number: _____

Test date: _____

Date of birth: _____

Age: _____

Event specialising in: _____

Highest level of performance: _____

Mass (kg): _____

Height (cm): _____

	% Body Fat	Body Fat Mass (kg)	Lean Body Mass (kg)
BOD POD			
BIA			
BMI			

