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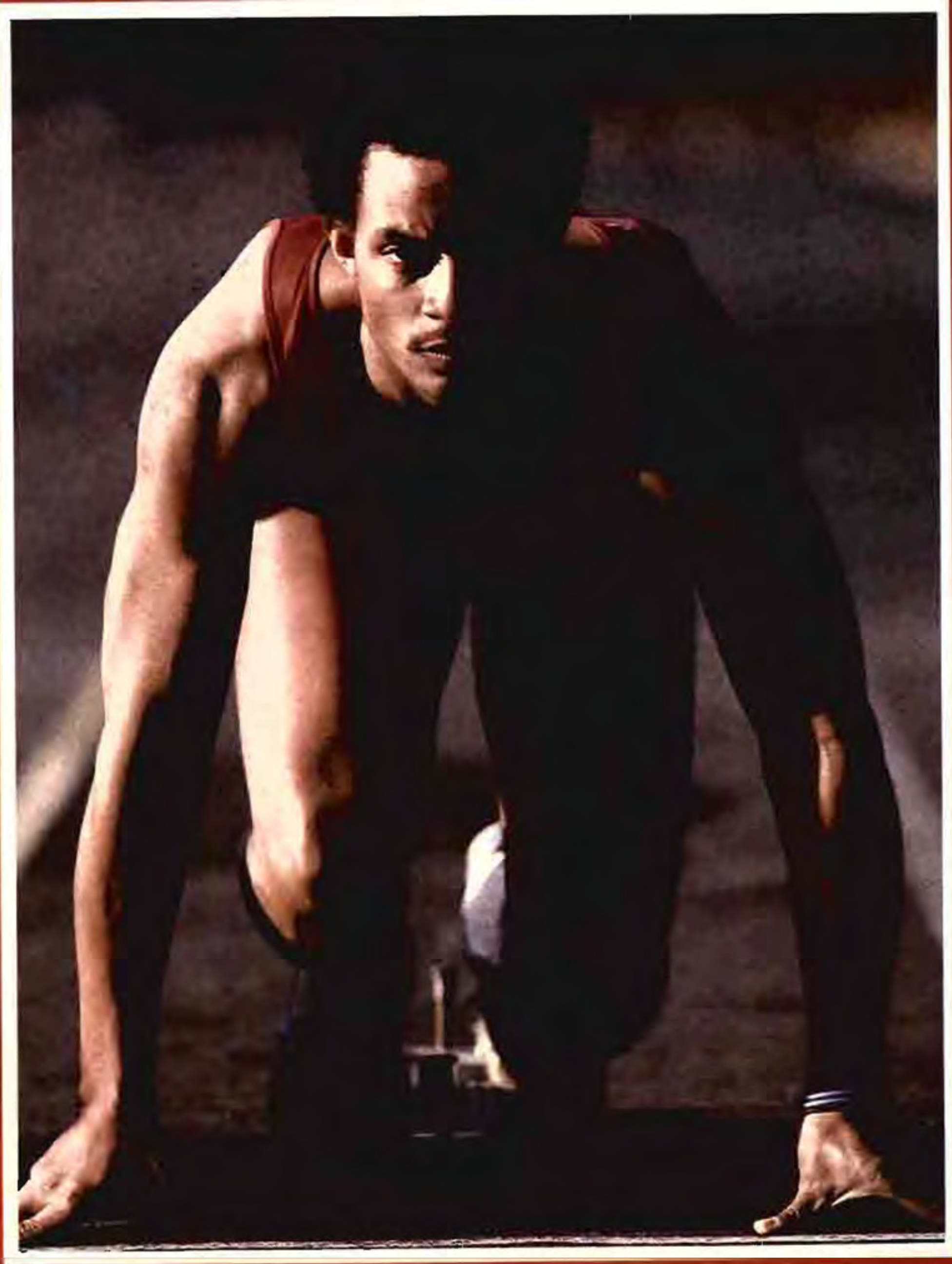

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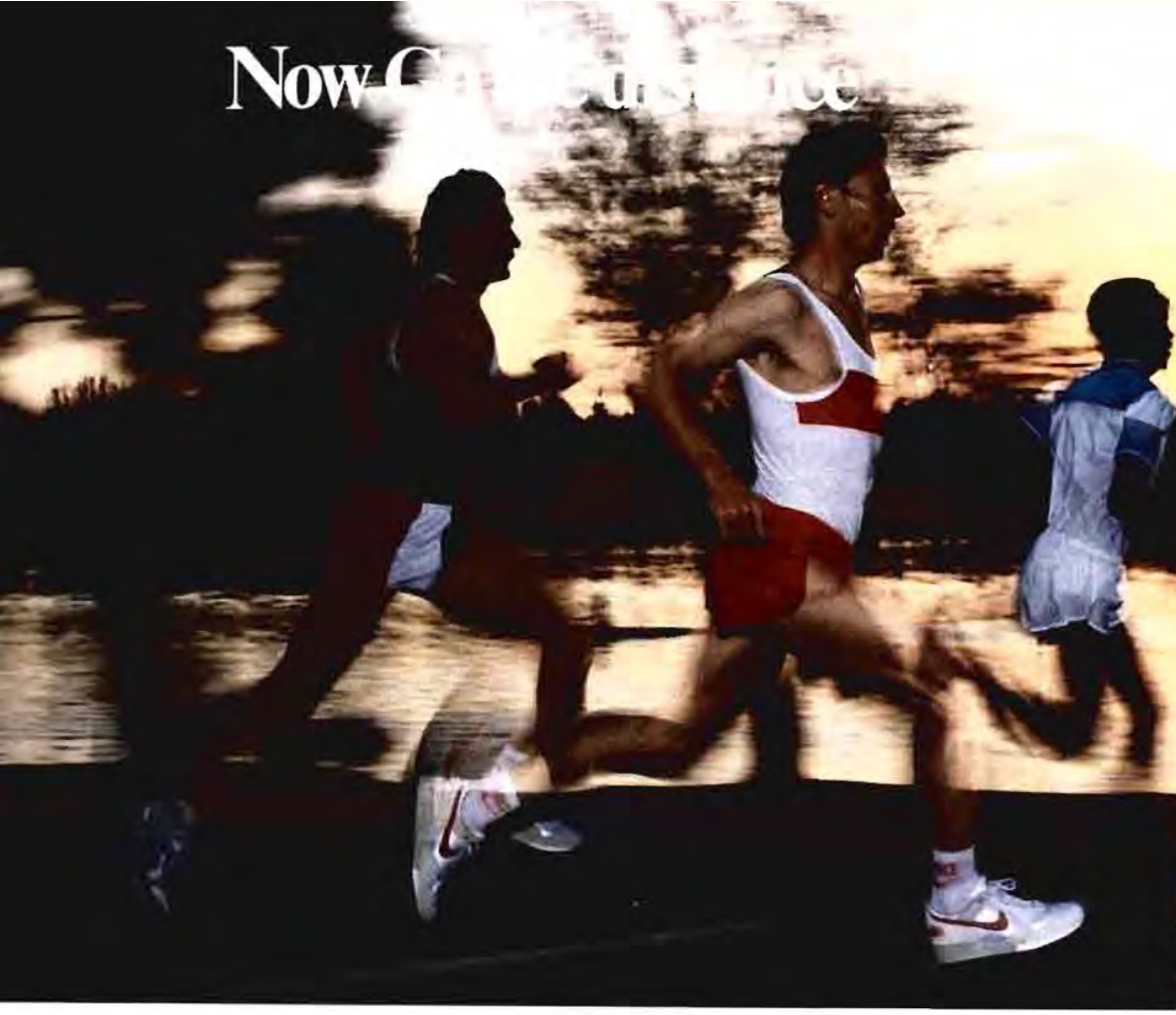
- **The influence of a shock-absorbing innersole on the incidence of exertion-related injuries**
- **Energy value of food**
- **Die waarde van pre-seisoensevaluering en post-traumatiese fisieke rehabilitasie**



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SPORTS MEDICINE IN SOUTH AFRICA

The Sports Medicine Association of South Africa (S.A.S.M.A.) is only six years old. Those of us who were involved in its foundation know that it took as many years before S.A.S.M.A.'s foundation to finally start an association. Now almost six years later one must look at what we have achieved and attempt to assess our future.

When we first began we started as a group of doctors under the auspices of the South African Medical Association. This means that only members of the medical profession are allowed to vote but affiliate members can be co-opted onto the association. These affiliate members must be people of standing in sports science, e.g. sports physiotherapists. As only a small number of doctors have a special interest in sports medicine this means that our association will always remain small.

There are however a number of ways that we can change this situation. Firstly we can educate more doctors so that a greater general interest in sports medicine can be stimulated. This can be done in a number of ways. This journal is a major asset in this regard. By publishing interesting articles more and more doctors may become interested and join our association. Lecturing and congresses by sports medicine specialists may also help in this regard. Unfortunately Cape Town University have the only facility under guidance of Professor Tim Noakes that has a direct involvement with sports science. Other universities require similar establishments. At grass roots level sports medicine should be taught to under graduate students. At present I know of no such teaching. With leisure time increasing more and more people are taking part in sport and therefore sports medicine will become progressively more important.

Finally one must consider a sports medicine association that will include all interested parties and not just doctors. In the U.S.A the American College of Sports Medicine fulfills this role. Here coaches, trainers, physiotherapists, dieticians, doctors, etc. all may belong to this Association. Possibly even two associations may be feasible.

It is imperative that in this next decade leading up to the year 2000 sports medicine and its association should go from strength to strength.

Dr. Clive Noble MBBCh, FCS(SA)
Editor-in-Chief

THE INFLUENCE OF A SHOCK-ABSORBING INNERSOLE ON THE INCIDENCE OF EXERTION-RELATED INJURIES SUSTAINED BY MILITARY RECRUITS

HJ van Heerden, PE Krüger, NF Gordon, JF Cilliers, AD Hales, AR Oberholzer

ABSTRACT *Keywords: shock-absorbing innersole, exertion-related injuries, military recruits*

The aim of this study was to determine the influence of a shock-absorbing innersole on the incidence of exertion-related injuries, of the lower extremities, among recruits during basic training in the South African Army. Injuries were classified according to the presence (group 1) or absence (group 2) of an obvious precipitating event, which allowed for the respective interpretation of a traumatic or overuse injury. Group 1-injury incidence (G1) was lower than the group 2-injury incidence (G2) for both the Standard boot (ST) and the shock-absorbing boot (SO) (ST-G1 = 1,1% vs G2 = 16,0%; SO-G1 = 1,0% vs G2 = 9,8%), indicating a predominance of overuse injuries. The variation in G1-injury incidence per boot type was negligible and insignificant ($p>0,1$). The difference between the STG2 and SOG2 injury incidence was significant ($p\leq0,05$), as was the case for total recruit injury incidence (ST = 17,1% vs SO = 10,8%) but to a lesser degree ($p<0,1$). The SO thus provided significantly better protection against the risk of exertion-related injuries. This was especially the case in respect of overuse injuries of the lower extremities during basic training. This observation was attributable to the effective functioning of the shock-absorbing innersole within the boot.

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The strenuous demands placed on the musculoskeletal structure of military recruits undergoing their initial period of intensive training and physical conditioning (basic training) can at times be excessive. This observation is reflected by the high incidence of injury, primarily to the lower extremities, that have been reported for both foreign forces,[1-3] and the South African Army.[4] Bensel[1] and Kowal[2] noted a 37% and 26% injury rate for American Marines and Army recruits respectively, while Stacy and Hungerford[3] recorded an alarming 65,4% incidence of "work-related" injuries among New Zealand Army recruits. In the South African Army, Gordon *et al*[4] documented a 37,9% incidence of exertion-related injuries sustained by recruits during basic training.

The transition from civilian footwear to military footwear has been implicated by various researchers as an important factor in contributing to the incidence of exertion-related injuries, of the lower extremities, among recruits.[5-7] The fact that civilian footwear constructed from materials that are lighter and have better shock absorption qualities than military footwear, may have an influence on the amount of stress incurred by individuals engaged in training.[8] As a result there has been growing support for the use of athletic footwear such as running shoes, for physical conditioning by many military units.[7,9,10,11] Whilst this approach has been accepted and introduced in the South African Army,[12] some foreign commanders have countered this advocacy, by reasoning that since the soldier fights in the boot, he should train in the boot.[11] As a further prophylaxis, attention has been focused on the modification of the military boot as another means of decreasing the incidence of injury among recruits.[1,3,8,10,13]

In order to investigate the effect of such a preventive measure, a study was conducted to determine the influence of two different boot types, on the incidence of exertion-related injuries of the lower extremities among recruits during basic training in the South African Army.

SUBJECTS AND METHODS

In this study National Servicemen that presented themselves for the February 1987 intake at a South African Army basic training centre served as subjects. All subjects underwent a comprehensive medical examination before commencing with basic training and only those that were classified as medically fit, were considered for the study. Initially a total of 750 subjects formed the sample, but primarily as a result of transfers to other units, 280 subjects were withdrawn within the duration of the study. The subject's average age was 19,8 years. Before the start of the project all subjects were informed about the purpose of the study and the procedure that was to be followed.

The subjects were issued randomly with one of the two types of boots, until an experimental group of 250 and one control group of 500 subjects was formed. During the issueing procedure recruits had their feet measured by members of the South African Bureau of Standards on a measuring device designed specifically for the military last according to the mondopoint system. Any further problems were resolved by the personal attention of a Podiatrist.

Figure 1: The standard leather boot type

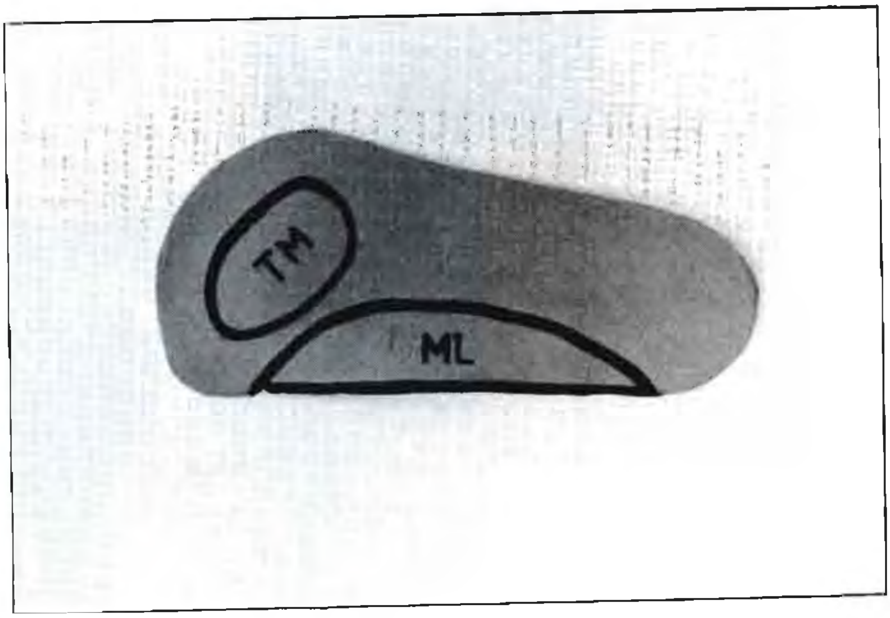

Figure 2: The shock-absorbing innersole

DESCRIPTION OF THE DIFFERENT BOOT TYPES

(As documented by the South African Bureau of Standards).[14]

Standard boot type

The current standard issue leather boot of the South African Army, is known as the "Vasbyt" boot. This boot is referred to as the Standard boot (ST) in this study and was worn by the control group (Figure 1).

Sorbothane boot type

The experimental boot then is referred to as the Sorbothane boot (SO) in this study. This boot was identical to the Standard boot, except for the inclusion of a shock-absorbing innersole. The innersole was specially designed and produced from a material known as Sorbothane. Sorbothane is the trade name for a type of visco-elastic polymer with specific properties well known for its unique cushioning and shock-absorbing capabilities.[16-20] An examination of the innersole reveals a build-up in the two main arches of the foot:

- the medial longitudinal arch (ML); and
- the transverse metatarsal arch (TM). The innersole proceeds from the heel of the foot to just posterior of the metatarsal heads (Figure 2).

THE BASIC TRAINING PROGRAMME

The basic training programme was performed over a 10 week period. During practical training recruits were subjected to physical conditioning following activities:

- military drill;
- field training; and
- physical training.

Drill training took place for one or more periods of 40-55 minutes each per day. During field training recruits completed strenuous navigational and route marches of 10-20 km. In accordance with footwear regulations recruits wore boots throughout drill and field training.

The physical training programme was followed for at least 4 periods of 40 minutes each per week over the full 10 weeks and was of a cyclic-progressive nature.[12] All exercises were performed strictly according to prescription.[21] During all organised physical training periods running shoes are worn and not boots or "takkies".

RESEARCH PROTOCOL

For the purposes of this study the same protocol was followed as was used by Gordon *et al*,[4] as regards the definition of an injury, classification of injuries and the method of data collection.

RESULTS

Recruit injury incidence and type of injury per boot type (Table 1)

The group 1-injury incidence (i.e. injury in the presence of an obvious sudden precipitating event) was lower than the group 2-injury incidence (i.e. injury in the absence of an obvious sudden precipitating event) for both the Standard (ST) and the Sorbothane (SO) boot types (ST = 1,1% vs 16,0%; SO = 1,0% vs 9,8%). The differences in the group 1-injury incidence between the two boot types (ST = 1,1% vs SO = 1,0%) was negligible and insignificant ($p > 0,1$). The variation in the group 2-injury incidence showed a significant difference (ST = 16,0% vs SO = 9,8%; $p \leq 0,05$), as was the case for the total recruit injury incidence (ST = 17,1% vs SO = 10,8%) but to a lesser degree ($p < 0,1$).

ANATOMICAL SITES OF INJURY PER BOOT TYPE

Group 1-injuries were sustained at only three anatomical sites, namely the ankle (ST = 33,3%), knee (ST = 66,7%; SO

Table 1: The recruit injury incidence and type of injury per boot type

Type of injury	Boot type: Standard (N=275) n	%	Sorbothane (N=195) n	%	Significance by Fisher's Exact Test
Group 1	3	1,1	2	1,0	NS
Group 2	44	16,0	19	9,8	p≤0,05
Total	**47**	**17,1**	**21**	**10,8**	**p<0,1**

n = No. of injured recruits
N = No. of recruits per boot type

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= 33,3%) and thigh (SO = 66,7%). Group 2-injuries (Figure 3) primarily affected the knee (ST = 32,6%; SO = 38,1%), lower leg (ST and SO = 28,6%) and Achilles tendon (ST = 16,3%; SO = 14,3%) for both boot types while the remaining anatomical sites, namely the foot, heel, ankle and thigh followed in frequency with a lower incidence.

LOSS OF BASIC-TRAINING TIME PER BOOT TYPE

The difference in the total incidence of training days lost as a result of exercise-related injuries per boot type was negligible (ST = 2,8%; SO = 2,2%). The incidence of training days lost due to group 1-injuries was notably less than that for group 2-injuries for both boot types (ST = 8,2% vs 91,8%; SO = 6,3% vs 93,7%). Figure 4 reflects the incidence of training days lost due to group 2-injuries per boot type at the various anatomical sites.

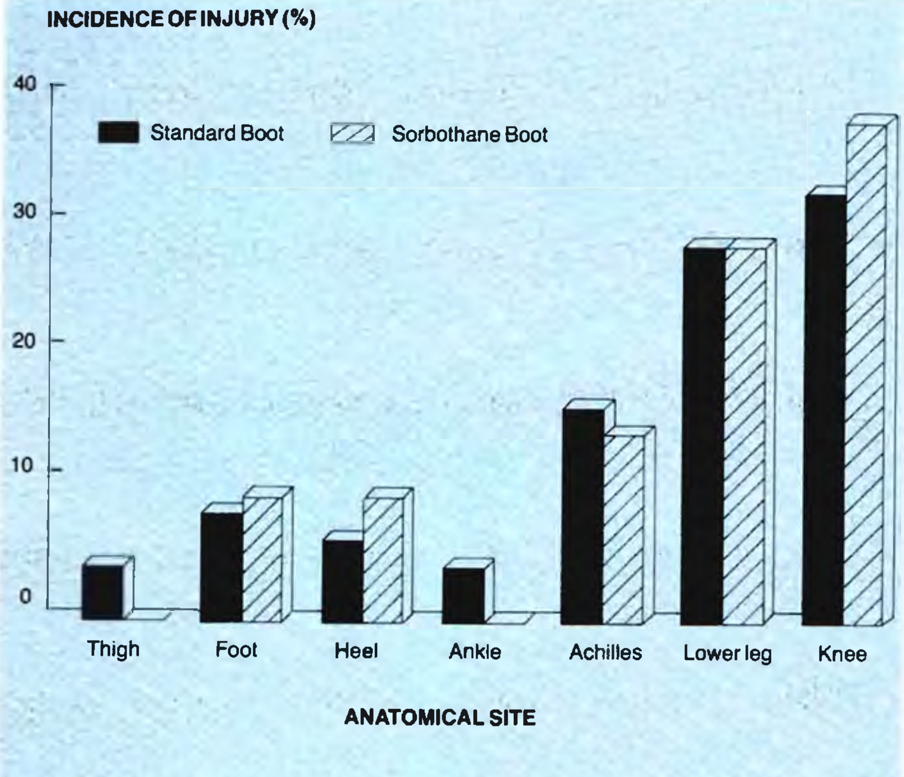

Figure 3: Anatomical distribution of Group 2-injuries per boot type

DISCUSSION

The vast majority of exercise-related injuries incurred by recruits in this study were inflicted in the absence of an obvious sudden precipitating event and can, for practical purposes, be regarded as overuse injuries. This finding is in accordance with that of Gordon *et al*[4] for South African Army recruits. In this study the SO fared significantly better than the ST (ST = 16,0% vs SO = 9,8%; $p \leq 0,05$) as regards the incidence of overuse injuries (group 2). A number of researchers[22-24] regard an accumulation of microtrauma during stereotyped, cyclic activities such as running as a major etiological factor in the incidence of overuse injuries, while others [25-27] suggest that a lack of shock-absorbtion in training footwear accentuates this problem. The effective functioning of the shock-absorbing Sorbothane innersole in the SO as opposed to the ST in this study, thus encourages support for the above opinions.[22-77]

The anatomical distribution of group 2-injuries in this study shows similarities with both civilian[28-31] and military[2,4,7] populations where the knee,

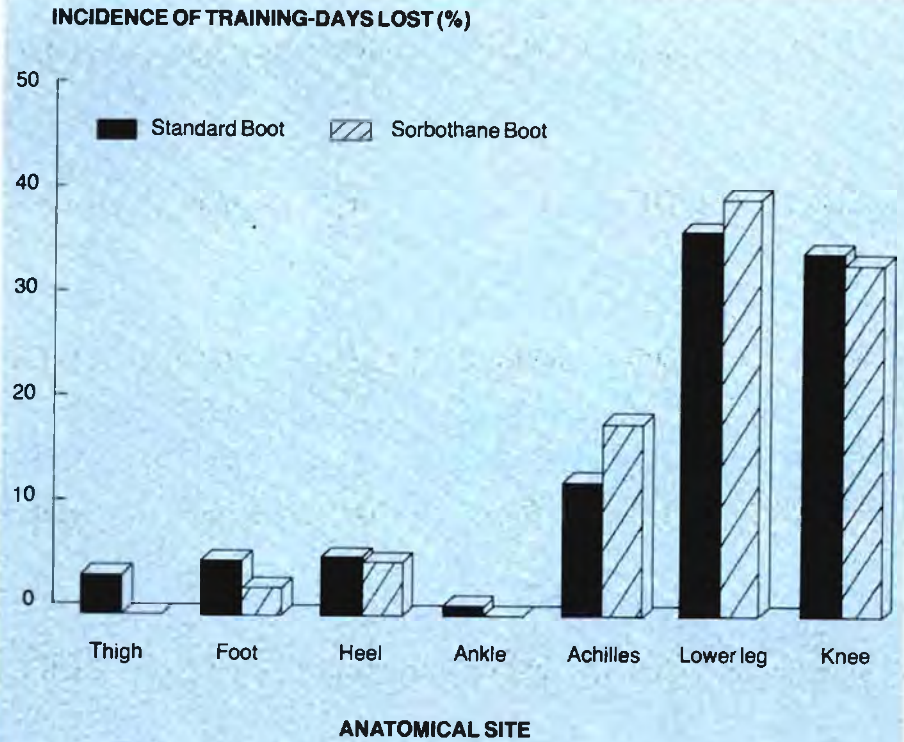

Figure 4: Anatomical distribution of training days lost due to Group 2 – injuries per boot type

lower leg and Achilles tendon suffered the highest incidence of overuse injury, compared to other anatomical sites of the lower extremities. Although the SO showed lower overall overuse injury incidence than the ST, it did however have a higher incidence of group 2-knee injuries than the ST (ST = 32,6% vs SO = 38,1%). This could possibly be attributed to the design of the SO innersole (Figure 2), where the build-up of the medial longitudinal arch may have caused an altered foot position in a recruit with no foot abnormality.[34] Such an induced anatomical malalignment could have predisposed the wearer to injury in the area of the knee.[26,32,33]

While the knee sustained the highest group 2-injury incidence for both boot types in this study (Figure 3), lower leg injuries caused the greatest loss of training days (Figure 4). This observation implies that overuse of the lower leg were of a more serious nature than knee injuries. This finding is in agreement with a previous study[4] among South African Army recruits.

Only a few studies have been published that specifically concentrate on improving the shock-absorbing capabilities of the combat boot, in an attempt to reduce the incidence of injury among recruits during basic training.[8,10,13] In making a biomechanical comparison between running shoes and combat boots, de Moya[10] found that cadets wearing combat boots experienced maximum vertical force readings of over 3 times body weight, while the use of inserts (Saran) within the boot significantly improved the cushioning response to impact. Milgrom *et al*[13] conducted a study to evaluate the effect of a shock-absorbing orthotic (PPT-Langer) on the incidence of stress fractures in military recruits. Their findings showed that the concept of orthotic prophylaxis significantly lowered the incidence of femoral stress fractures which they considered to be potentially the most dangerous; due to their tendency to be "silent" for long periods and their risk to evolve into displaced stress fractures.[13] For the purpose of determining whether fewer injuries would occur from using cushioned innersoles (Spenco and Poron), Smith *et al*[8] modified the boot used for all training and marching by the United States Coast Guard. Their findings showed that the control group has the highest injury incidence (62,5%) during basic training, followed by the Poron and Spenco groups with 26% and 14,2% respectively, while the overall comfort of the boot was also enhanced with the use of the shock-absorbing innersoles.

CONCLUSION

The results of our and the above studies[8,10,13] indicate that an improvement in the shock-absorbing capabilities of the combat boot is required, if the high incidence of injury among recruits during basic training[1-4] is to be reduced. Although differences in research protocols and the material used in these studies[8,10,13] disqualifies an accurate comparison with each other and with the results of this study, a measure of correlation can be deduced. In this and the studies of de Moya,[10] Milgrom *et al*[13] and Smith *et al*,[8] the modification of placing shock-absorbing innersoles within combat boots, resulted in a lower incidence of injury, compared to the standard combat boot, confirming the success of this prophylactic approach.

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ENERGY VALUE OF FOOD

M Faber

ENERGY INTAKE

The main difference between the athletes diet and the diet of the general population can be found in the level of energy intake. Energy requirements of the athlete depend not only on the type of exercise, but also on the time used performing the activity. In other words, the energy requirements may vary over time according to the physical training programme of the athlete. To maintain good performance, the energy intake must equal the energy expenditure. This will result in the body weight remaining more or less stable. The body weight of an athlete can be an indication whether he is consuming sufficient energy. Energy imbalance will be evident by changes in body weight. If energy imbalance occurs, the individual will either lose or gain weight. If the energy content of the food ingested is less than the energy output, i.e. if the energy balance is negative, endogenous stores namely glycogen, fat and body protein are utilised and the individual loses weight. If the energy value of the food intake exceeds energy expenditure, the balance is positive and energy is stored as adipose tissue and the individual gains weight. Each kilogram of adipose tissue (fat) represents the storage of about 7000 kcal (29300 kJ). If the athlete is overweight and should lose weight, a steady weight loss of 0,5 to 1,0 kg per week is recommended. To achieve this weight loss, the energy deficit should be between 3500 and 7000 kcal(14650 and 29300 kJ) per week.

Mieke Faber

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WHERE DOES THE ENERGY IN THE DIET COME FROM?

The energy value of the diet is expressed in either calories (kcal) or kilojoules (kJ). One kcal equals 4,186 kJ. The energy value of different food items is determined by the carbohydrate, protein and fat content of food. Alcohol may also contribute to the energy content of the diet.

1 g carbohydrate supplies 4 kcal(17 kJ)
1 g protein supplies 4 kcal(17 kJ)
1 g fat supplies 9 kcal(37 kJ)
1 g alcohol supplies 7 kcal(29 kJ)

A calorie is a calorie, whether it comes from carbohydrate, protein or fat. Most ordinary foods are combinations of protein, carbohydrate, fat, and it also contains variable amounts of water (some as high as 90%). It also contains vitamins and minerals. Foods that have a high water content, such as fruit and vegetables, have small quantities of protein, carbohydrates and fat and are therefore relatively low in calories. Foods which contain little or no water, eg sugar (with plenty carbohydrates), oil and fats (with plenty fat) are loaded with energy. A great disadvantage of many of the energy loaded foods is that they often provide little more than energy. An imbalance between the energy intake and nutrient intake is therefore the result. The fact that food contains water can lead to many misconceptions concerning the energy, protein and carbohydrate content of food. For example, meat is known as a high protein food. This does not mean that 30 g of meat equals 30 g of protein. In fact, 30 g meat supplies on the average only 7 g protein and 5 g fat. The remaining 18 g (60%) is mostly water, which supplies no energy. Even when all the visible fat is removed from meat, it still contains variable proportions of invisible fat which are closely associated with other constituents in an emulsion or as part of the tissue. When planning an eating pattern, energy intake is not the only determining factor. Factors such as protein needs, vitamin and mineral requirements and adverse effects of high fat intakes should also be taken into consideration. A BALANCED diet, composed of the three macro-nutrients (carbohydrates, protein and fat) plus vitamins and minerals, is necessary for proper nutrition. It is quite possible to consume adequate amounts of energy, but because of poor food choices, be malnourished due to certain nutrient deficiencies. It must be kept in mind that fats and sugar do not contain protein and minerals. When they constitute a large proportion of the total energy intake, there is a danger that other nutrient needs will not be met. Assuming that energy needs are met, the following energy distribution is recommended:

- at least 55% of the energy should be supplied by carbohydrates;
- 12-15% of the energy should be supplied by protein;

- fat should not exceed 30% of the total energy intake.

The quantity of food is definitely no indication of energy intake. To increase the bulk of the diet, foods with a lower energy density (fewer kcal/100 g) can be consumed. An example of a food item with a low energy density is an apple (58 kcal/100g) compared to chocolates which has a high energy density (520 kcal/100g). The greatest pitfall in energy intake is the fats one is not aware of (invisible fats), such as fat in fried foods, melted butter in hot vegetables, cream in soups and sauces, salad dressings and rich baked products.

Foods can be grouped together according to their carbohydrate, protein and fat content. Each group contains foods that are more or less alike. The average macro-nutrient content for these groups are summarised in the following table. This table can be used as a guideline in planning the daily energy intake.

Table 1: Kcal and macro-nutrient content of foods

	Quantity	CHO (g)	Protein (g)	Fat (g)	Energy (kcal)
Starch/bread	30g bread or 125 mL cereal or 125 mL pasta* or 125 mL grain* or 125 mL rice*	15	3	trace	80
Lean meat	90 g	-	21	9	165
Medium-fat meat	90 g	-	21	15	225
High-fat meat	90 g	-	21	24	300
Vegetables	125 mL cooked or 250 mL raw	5	2	-	25
Fruit	125 mL fresh fruit or 125 mL juice or 62 mL dried fruit	15	-	-	60
Skim milk	250 mL	12	8	trace	90
Low-fat milk	250 mL	12	8	5	120
Whole milk	250 mL	12	8	8	150
Fat	5 g 1 teaspoon	-	-	5	45

* Cooked values

DIE WAARDE VAN PRE-SEISOENSEVALUERING EN POST-TRAUMATIESE FISIEKE REHABILITASIE

DDJ Malan

INLEIDING

Die afgelope dekade is die sportwêreld en deelname aan fisieke aktiwiteit gekenmerk deur die "fitness boom" wat voorgekom het. Nie alleen het die nuwe bedrywe tot stand laat kom nie, maar ook 'n deels onverwagte uitdaging aan die sportgeneeskundige professie gestel. Die voorkoms van beserings tydens deelname aan sport en fisieke aktiwiteite het weens die deelnemerstal bykans maandeliks toegeneem.

Gepaardgande hiermee is die sportgeneeskundiges en lateraan ook die oefenkundiges met 'n andersoortige benadering ten opsigte van die beoordeling en behandeling van beserings tydens deelname gekonfronteer. Gedurende die sestiger- en sewentigerjare het die klem hoofsaaklik geval op die diagnose en behandeling van akute beserings, terwyl die analise van die voorkomende aspekte weinig aandag geniet het (Stanish, 1984:1). Hierdie aanvanklike gebrek en eensydige benadering het egter bygedra tot die meer professionele spanbenadering in die voorkomende en rehabiliterende fases van sportbeserings. Op verskeie terreine van sport en fisieke aktiwiteit is doelgerigte opleidingspakkette ter verbetering van afrigters en programleiers se basiese kennis oor oefenkundige aspekte tydens deelname, daargestel. Binne 'n bestek van sowat 5 jaar het daar veral op die terrein van die oefenkundige aspekte, 'n meer bewuste en kundige benadering voorgekom. Dit is egter ook waar dat die gevare verbonde aan oefenprogramvoorskrif deur verskeie aanbieders geïgnoreer word weens die gebrek aan opleiding, met 'n gevolglike hoë insidensie van beserings wat by diesulke persone se groepe voorkom. Dieselfde tendens word volgens Stanish (1984:1) ook in Kanada aangetref, waar daar selfs meer aandag aan opleiding gegee word. Selfs op skoolvlak word daar tans 'n voorkomende benadering tot fisieke aktiwiteitsdeelname gevolg.

'n Verdere uitvloeisel van hierdie toenemende probleem waarmee sportgeneeskundiges en oefenkundiges worstel, is die daarstelling van seminaargeleenthede waar kundiges gedagtes kan uitruil en kennis oor die voorkoming en behandeling van beserings kan oordra. Dink maar net in hierdie geval aan die totstandkoming van ons eie Sportgeneeskundige Vereniging, asook die werksaamhede van SAVSLOR (Suid-Afrikaanse Vereniging vir Sportwetenskap Liggaamlike Opvoedkunde en Rekreasiekunde) op die terreine van Oefenkunde en Biokinetika in die geval van laasgenoemde organisasie. In meeste opsigte is die dienste van die multidissiplinêre span op die gesondheidsorg van die deelnemers ingestel.

Beserings in sport en fisieke aktiwiteit toon groot wisseling. Kontaksport is algemeen bekend vir die hoë insidensie van beserings, maar niemand het gedagte gehad dat die deelname aan aerobiese dansoefeninge so 'n magdom beserings tot gevolg sal hê nie. Wat in hierdie twee uiterstes van aktiwiteite veral opvallend is, is dat die voorkoms van dieselfde tipe besering, aan totaal verskillende oorsake toegeskryf kan word. So byvoorbeeld kan 'n swak fisieke spiervermoë in die geval van die rugbyspeler aanleiding gegee het tot die besering, terwyl onkundigheid oor programuitvoering in die geval van die aerobiese dans deelnemer as oorsaak voorgehou kan word.

Daar is bereken dat gedurende 1983 sowat 20% van die Amerikaanse bevolking aan hardloopaktiwiteite deelgeneem het (Stanish, 1984:1). 'n Verdere 10% het aan 'n verskeidenheid ander sport en fisieke aktiwiteite deelgeneem wat potensieël tot beserings kon aanleiding gee. Dit mag dalk die indruk van 'n baie gesonde gemeenskap gee, wat wel ook waar is, maar weens die toename is beseringsinsidensie blyk dit eerder 'n "beseerde" gesonde gemeenskap te wees. Op geen wyse is medici in staat om bo-en-behalwe hul normale behandeling van siektetoestande ook nog met die behandeling van beserings tydens fisieke aktiwiteit vol ten hou nie. Op een of ander wyse genoodsaak dit 'n profilaktiese benadering.

Deelname aan sport en selfs fisieke aktiwiteite in die algemeen kan soms bomenslike eise aan die fisieke vermoë van die liggaam stel. Dit het daartoe bygedra dat die voorbereiding van veral sportlui meer gesofistikeerd en gespesialiseerd geraak het, vanwee die meer wetenskaplike benadering van afrigters. Dit is oor die afgelope 40 jaar sterk aangespoor en ondersteun deur 'n "navorsingsontploffing" op die terrein van die sportgeneeskunde.

Ten spyte van die meer wetenskaplike benadering van sportafrigting, is dit bykans onmoontlik om die sportdeelnemer se "spook" – 'n sportbesering – tydens deelname weg te hou. Ongeag na watter sportsoort gekyk word, bly die traumatiese ervaring van 'n besering die grootste terugslag wat 'n deelnemer kan ervaar.

Suid-Afrika gaan deels nog gebuk onder afrigters/programleiers wat nie vatbaar vir "inmenging" is nie en sodoende hulself as alwetend beskou. So-

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danige benadering weerspieël 'n gebrek aan kundigheid en stel hulself en ongelukkig ook die sportlui aan gebrekkige vordering en ander probleme bloot. Die teenoorgestelde is egter ook waar. Die afrigter/programleier beskou hulself as spesialiste op hul terrein, maar ag dit nodig om ander ondersteunende kundiges te nader ter wille van die voordele daarvan aan die deelnemers. Sodanige wisselwerking is 'n direkte aanknopingspunt tot die profilaktiese benadering tot beserings tydens deelname aan sport en fisieke aktiwiteit.

PRE-SEISOENSEVALUERING

Verskeie wetenskaplikes (o.a. Hunter et al., 1979:205; Noble, 1980:12; Watson, 1981:47 & Rice, 1984:192) maak melding van die verskeidenheid van wyses waardeur beserings tydens deelname voorkom kan word. Voorstelle in hierdie verband het gewissel van wetenskaplike opleiding van afrigters/programleiers tot verandering aan die reëls van die spel. Een van die uitstaande faktore wat in die navorsing na vore gekom het, is die eenstemmigheid oor die belangrikheid en waarde van pre-seisoensevaluering. Nie allen word dit as 'n voorkomende maatreël gestel nie, maar hou dit ook bepaalde voordele in indien die deelnemer later beseer sou raak.

Appen en Duncan (1986:232) verklaar dat pre-seisoensevaluering a riglyn gebruik kan word om die deelnemer se gereedheid vir deelname aan 'n bepaalde sport te kan bepaal. Hieruit kan afgelei word dat die deelnemer se fisieke toerusting net so belangrik is as die toerusting waarmee die aktiwiteit beoefen moet word.

Pre-seisoensevaluering dien ook as metode waardeur "swak skakels" in die fisieke mondering van deelnemers geïdentifiseer kan word. Sodoende kan daar dan met die korrekte inoefeningsmetodes, 'n regstelling van die tekortkominge gemaak word, waardeur die moontlike oorsaak van beserings verminder kan word.

Watson (1981:417) beklemtoon die voorafbepaling van sportdeelnemers se fisieke toestand. In hul navorsing is 0/15 en 0/16 rugbyspelers aan 'n fisieke preseisoensevaluering onderwerp. Sy bevinding was dat die deelnemers se krag, grootte en sukses tydens deelname nie as waarborg moet dien vir die afwesigheid van fisieke tekortkominge nie. Die navorsing het duidelik gedui op die noodsaaklikheid van preseisoensevaluering reeds op jong ouderdom, ten einde individuele verskille te kan aandui asook om op daardie ouderdom reeds fisieke tekortkominge te kan regstel. Watson (1981:421) beklemtoon die noodsaaklikheid na evalueringsmetodes wat vinnig en effektief deur afrigters/programleirs uitgevoer kan word. Rice (1984:192) meld dat aanbevelings deur die sportgeneeskundiges en sportverenigings in die V.S.A. daarop is om alle deelnemers aan sport op Hoërskoolvlak, jaarliks aan 'n pre-seisoensevaluering bloot te stel. In hul ondersoek is vasgestel dat 70% van die persone wat na 'n jaar ge-herevalueer is, bepaalde diskwalifiserende probleme vertoon het, waarvan 55% een of ander vorm van muskulo-skeletale of ortopediese probleem was.

Strydom (1985:7) verwys ook na die neiging dat afrigters meer spesifiek is in hul voorbereidingsmetodes van sportlui. Twee provinsiale rugbyspanne het in 1984 'n poging aangewend om hul spelers aan pre-seisoensevaluering te onderwerp. Weens die belangrikheid van die kompetisie en die gesindheid van die spelers is die navorsing nie na wense voltooi nie, en is daar nog weinig inligting hieroor beskikbaar. Navorsing deur die Instituut van Sportnavorsing en -Opleiding het in 1985 resultate verkry wat dui op die afname van fisieke vermoë namate die seisoen verloop het. Sonder preseisoensevaluering sou sodanige afleiding nie gemaak kon word nie.

Uit gesprekke met medici en ortopediste het dit geblyk dat preseisoensevaluering van groot waarde is in die diagnose van 'n beseerde deelnemer. Dit is egter nie haalbaar om sodanige evaluering op elke deelnemer toe te pas nie, maar kan dit aanvanklik veral op deelnemers van hoë standaard toegepas word ten einde 'n verwysingsraamwerk daar te stel. Op verskeie geleenthede is die opmerking al gemaak dat die evaluering van 'n besering meer doeltreffend sou gewees het indien die resultaat van 'n preseisoensevaluering bekend was. So byvoorbeeld word, waar moontlik, by 1 Mil. Hospitaal 'n pre-operatiewe evaluering gedoen van pasiënte met 'n besering, ten einde fisieke rehabilitasie meer doeltreffend te kan maak.

Die noodsaaklikheid van pre-seisoensevaluering blyk duidelik uit die bogenoemde argumente en resultate. Ter opsomming kan die waarde van sodanige evaluering net weer kortliks aangestip word.

- Dit dien as metode waardeur fisieke tekortkominge waargeneem kan word;
- Identifisering en remediëring van "swak plekke" kan daartoe bydra dat die voorkoms van beserings verminder kan word;
- Dit stel die afrigter/programleier in staat om meer doelgerig met die inoefeningsprogram te handel;
- Dit dien as wyse waardeur delnemers op individuele grondslag beoordeel kan word en programvoorskrif daarvolgens kan geskied;
- Dit dien as basis waarteen opvolgevaluerings vergelyk kan word; en
- Tydens rehabilitasie dien dit as norm waaraan die herstelproses meer objektief beoordeel kan word.

POST-TRAUMATIESE FISIEKE REHABILITASIE

Dit is nie die oogmerk van hierdie lesing om verdiep te raak in die rehabilitasieprosedures en resultate van 'n enkele of wye verskeidenheid van muskulo-skeletale probleme nie. Die doel is meer op die waarde wat post-traumatiese fisieke rehabilitasie vir sportlui in die algemeen inhou, uit te lig.

Soos in die geval van 'n multidissiplinêre spanbenadering in die voorkoming van beserings, behoort dieselfde weg ook opgegaan te word in die rehabilitasie van 'n beseerde deelnemer. Die omvang van deelname, die toename in beseringsinsidensie en die kompleksiteit van rehabilitasie na die besering genoodsaak sodanige benadering.

Verskeie sentra in ons land kan as duidelike voorbeeld van die suksesvolle samewerking van medici, fisioterapeute en biokinetici in die rehabilitasie van beseerdes voorgehou word. 'n Praktiese voorbeeld van spanwerk in hierdie verband kan in die rehabilitasiesentrum by 1 Mil. Hosp. gesien word. Die span behaal uitstekende resultate met beseerde pasiënte wat muskulo-skeletale beserings opgedoen het.

Tydens 'n persoonlike besoek aan die VSA is gevind dat soortgelyke dienste aan verskeie sportklubs en privaatpraktyke gelewer word. Dit is nie vreemd om o.a. by van die Amerikaanse voetbalspanne so 'n sportgeneeskundige span aan te tref nie. Ten volle toegeruste rehabilitasiekamers waar akute en finale fase fisieke rehabilitasie uitgevoer word, is aan die orde van die die dag. Die waarde van rehabilitasie vir hierdie sportspanne moet gelees word in die effektiwiteit waarmeer die spelers tot die spel teruggeplaas word. 'n Algemene uitdrukking is dat die speler in 'n beter toestand aan die span terugbesorg word as waarin hy was voor die besering.

Een van die hoof doelstellings van rehabilitasie is om die persoon se funsionele vermoë te herstel. In die geval van professionele sportdeelnemers, is sodanige doelstelling nie voldoende nie. Daar word vereis dat die deelnemer so gou as moontlik tot die spel moet terugkeer. Die psigologiese impak van so 'n eis kan egter soms groter skade aanrig as die insidensie van die besering self. Effektiewe rehabilitasie kan soms 'n tydrowende proses wees waartydens die deelnemer soms nie geduld het om volle funsionele vermoë te herwin nie. Daar is gevalle in die VSA opgeteken waar spelers voorgegee het dat hulle ten volle herstel het, maar ondersoeke aangedui het dat funksionele vermoë nog nie ten volle herwin is nie. Doelgerigte posttraumatiese rehabilitasie kan in sommige opsigte hierdie soort van probleem oorbrug en die speler in die spel teruggeplaas sonder verlies aan fisieke vermoë.

Die waarde van post-traumatiese fisieke rehabilitasie lê opgeteken in die suksesse wat met sodanige programme behaal is. Die interaksie tussen die rehabilitasieprogram en die korrekte diagnose van die besering en/of die geslaagdheid van die chirurgiese prosedure kan in 'n groot mate die sukses van fisieke rehabilitasie bepaal. Fisieke rehabilitasie word soms ook gebruik om die geslaagdheid van die operasie in die herstel van funksionele vermoë te beoordeel. Ongeag na watter kant van die skaal gekyk word, het navorsing die waarde van finale fase fisieke rehabilitasie lank gelede reeds bevestig.

Verdik *et al* (1967) en Woo *et al.* (1979) het aangetoon dat gedurende submaksimale isokinetiese weerstandsinoefening, versterking van ligamente en tendons kan voorkom. Ter ondersteuning hiervan het Zukerman *et al.* (1969) en Tipton *et al.* (1970) vroeë reeds bevind dat weerstandsoefening die breekkrag en kragdravermoë van ligamente kan verhoog. Sodoende kan gegradeerde progressiewe weerstandsoefeninge van submaksimale tot maksimale intensiteit as stimulus vir groei en versterking van die ligamente dien. Hieruit kan afgelei word dat in gevalle met ligamentlaksiteit, -rekonstruksie en tendonskeurings, effektiewe funksionele herstel deur finale fase fisieke rehabilitasie bewerkstellig kan word.

Davies (1985:224-228) het aangetoon dat persone met patella subluksasie na slegs 6 weke van isokinetiese weerstandsinoefening 'n merkbare verbetering in kraglewering ondervind het. In hierdie studie is aangetoon dat abnormaliteite in die kragleweringskurwe, wat tiperend van hierdie probleem is, met fisieke rehabilitasie verwyder kan word. Die studie het ook aangetoon dat verbetering in die stabiliteit van die quadricepsmeganisme en -kraglewering, in 'n groot mate kan kompenseer vir die subluksasie van die patella. Ook in die geval van chondromalacia patellae en patellofemorale pyn is gevind dat fisieke rehabilitasie 'n effektiewe vermindering en selfs verdwyning van pyn kan teweegbring (Davies, 1985:237).

Davies (1985) het ook gevind dat persone met anterior kruisligament rekonstruksie, met aanvang van post-traumatiese rehabilitasie steeds soveel as 40% verlies van kraglewering het. Doelgerigte fisieke rehabilitasie kan hierdie verswakking egter binne enkele weke verwyder. Fisieke rehabilitasie sal egter nie net die pasiënt se spierkrag van die beseerde been normaliseer nie, maar ook tegelykertyd versterking van die gerekonstrueerde ligament laat plaasvind.

Die waarde van post-traumatiese fisieke rehabilitasie word ook in 'n omvattende ondersoek deur Cilliers (1985) aangedui. In hierdie navorsing met oorlogsbeseerdes is aangetoon dat selfs in 'n wye spektrum van beserings en patologies/ortopediese toestande, finale fase fisieke rehabilitasie op 'n wye terrein van waarde kan wees. Dit herstel nie net die funksionele vermoë van die pasiënt nie, maar lewer ook 'n bydrae in die verhoging van die individu se selfbeeld, selfvertroue en psigiese ingesteldheid ten opsigte van sy/haar situasie.

Ter opsomming kan die gedagte van "'n beter eindproduk" na fisieke rehabilitasie as kerngedagte voorgehou word. Deur die resultate van gerehabiliteerde deelnemers aan ander beseerde sportlui te toon, sal die waarde van hierdie belangrike fase in die behandeling van die persoon inslag vind.

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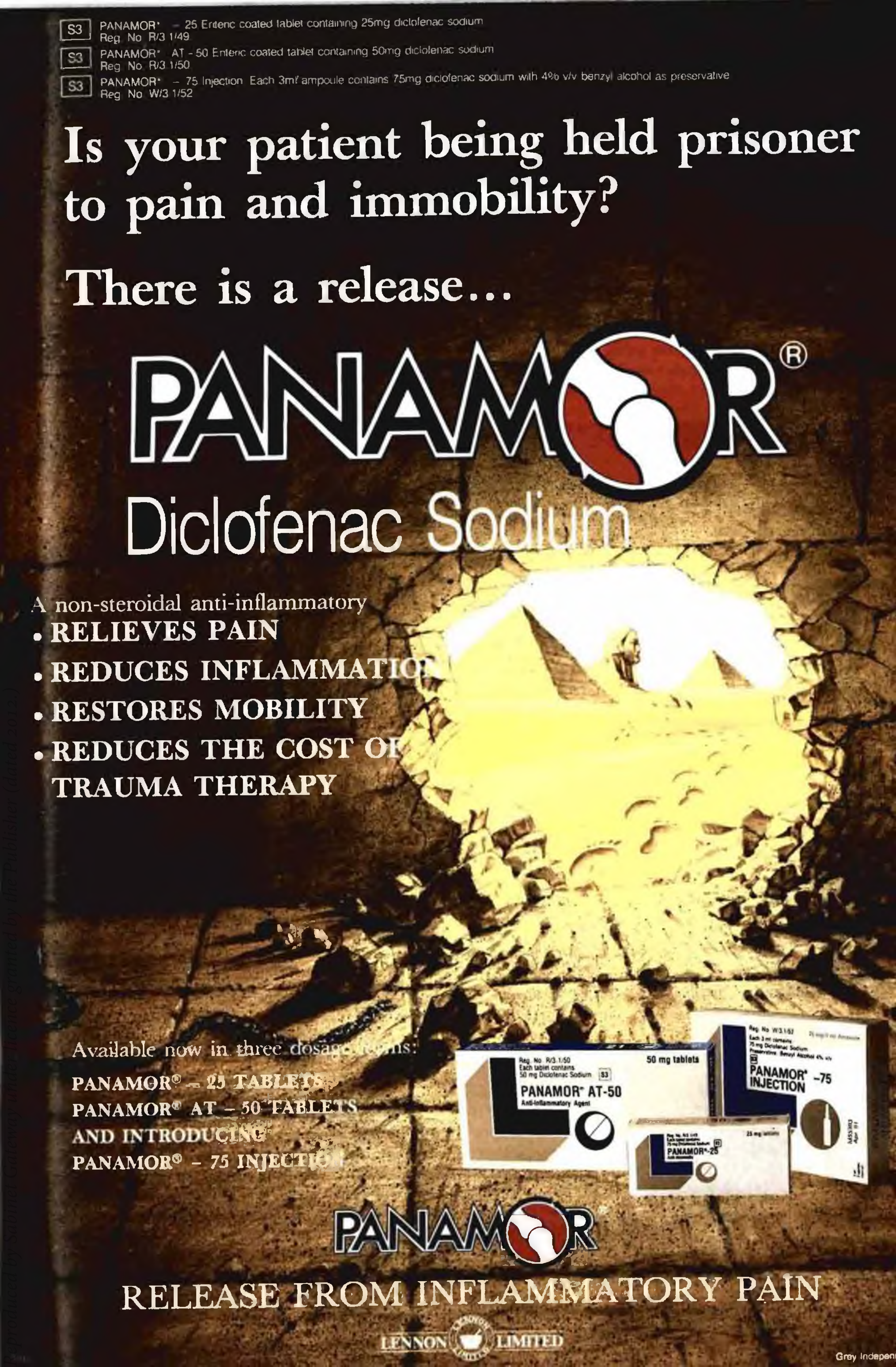
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AN EVALUATION OF HAMSTRING/QUADRICEP STRENGTH RATIOS IN ELITE LONG DISTANCE RUNNERS AND SPRINTERS

L Davimes and I Levinrad

ABSTRACT *Keywords: Hamstring/quadriceps strength ratios, normative, endurance runners, sprinters, cybex*

The purpose of this study was to investigate hamstring/quadricep strength ratios in long distance runners and sprinters. Hamstring/quadriceps strength ratios were obtained in twenty five elite long distance runners and twenty one sprinters at a testing speed of 60 degrees/sec on the Cybex II. Hamstrings were found to be 62% and 59% of quadriceps in sprinters and long distance runners respectively.

Sprinters generated significantly greater knee flexor and extensor muscle torque than long distance runners for both legs even when strength was expressed relative to body weight. No significant difference in strength between the dominant and nondominant legs was observed in sprinters. Dominant knee flexors were significantly stronger than nondominant flexors in long distance runners.

The study established normative data on hamstring/quadriceps strength ratios in the two types of running discipline. The ratio may provide a guide for prophylactic measures athletes can follow for safe participation in sprinting or running.

INTRODUCTION

Isokinetic strength testing can be used to identify muscle strength imbalance or weakness. The flexor/extensor strength balance is important in the stabilization of the knee and may be a factor in knee joint injury should the ratio be abnormal. Thus muscles or joints may be more prone to injury if the agonist and antagonist differ significantly in strength. Establishment of normal knee flexor/extensor ratios may be a necessary prophylactic measure against injury. It may be possible to identify an abnormal ratio early and this can be used as a warning sign to prevent injury. However, it is not clear at this stage what constitutes a normal and abnormal ratio. If research is to be done on identifying abnormal ratios then it is essential to establish a normal ratio.

In addition, in rehabilitation of an injured knee, progress is usually assessed by a comparison of strength of the injured knee with the non-injured contralateral knee. However, in bilateral knee injuries it is not known at what point the patient is rehabilitated and a comparison of the knee strengths will not allow a determination of reasonable rehabilitation goals. It is therefore important to know what normal ratios are before returning to sporting activities. Campbell and Glenn[3] concluded that attention should be directed to the hamstring/quadricep strength ratio in rehabilitation of the knee. Gosling [13] *et al* contended that knee rehabilitation is not complete unless extension:flexion was 2 : 1.

Normative data may differ in people involved in different sports since there are specific skills required in different sports and specific torque stresses an athlete is required to endure.[10] There may be a minimum hamstring/quadricep strength ratio an athlete should achieve in order to safely participate in a specific sport. Therefore it may be necessary to test hamstring/quadricep strength ratios in different sports. This study investigates strength ratios in runners.

A review of the literature has indicated that no normative data for hamstring/quadriceps strength ratios are available for long distance runners and

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sprinters. The purpose of this study was to establish normative hamstring/quadriceps strength ratios in long distance runners and sprinters. In addition, the knee flexors and extensors of long distance runners and sprinters will be compared. The dominant leg strength will be compared with the nondominant leg in each group of subjects.

METHOD

Selection of Subjects

Twenty five long distance runners (marathon runners or half marathon runners) and twenty three sprinters ages 17-32 years served as subjects in the study.

The protocol was passed by the committee for Research on Human Subjects.

Testing Device

The Cybex II was used as the testing device to determine strength developed by the limb during knee flexion and extension (Cybex Division, Lumex Inc., Bayshore, N.Y.). The dynamometer was calibrated according to the procedure suggested by the Cybex manufacturer. The cybex apparatus measures knee flexion and extension at a preset speed. During conventional exercise energy is mainly dissipated with accelerations in the exercise. The cybex mechanically prevents this dissipation of energy and converts it to a resisting force which is proportional to the muscular force.

Experimental Procedure

Gravitational Effect Torque (GET)
The Gravitational Effect Torque is the torque resulting from the effect of the gravity on the combined weight of the leg and the dynamometer arm.

GET was determined in order to ascertain correctly the relative strength of the antagonists inversely affected by gravity.

GET in ftlbs was obtained by locking the subjects knee into full extension and then instructing him to relax his quadriceps muscle. This was repeated again such that a consistent value was obtained.

Test on the Cybex after adequate warm up
The test was performed at 60 degrees/sec to determine strength of the hamstrings and quadriceps as individual muscles and as a ratio.

Analysis of Variance tests were used to compare runners with respect to age, mass, hamstring/quadriceps ratios and flexion and extension expressed relative to body weight.

Analysis of CoVariance tests were used to compensate for the effect of mass in flexion and extension. Dominance was compared with non dominance by a pairwise comparison of means. A linear regression analysis was completed for hamstring and quadriceps muscle torque versus total body weight. Pearson Correlations were calculated on each variable.

RESULTS

Physical characteristics of the subjects are presented in Table 1. There were significant differences in weight between sprinters and long distance runners.

The means and standard deviations for peak hamstring and quadriceps torque for left and right legs are presented in Table 2. The quadriceps possessed higher mean peak torque values than the hamstrings in both groups of subjects. Differences in hamstring and quadricep mean torque between sprinters and long distance runners were analysed. Sprinters were found to produce significantly greater mean peak hamstring and quadriceps torque than long distance runners. Peak flexor and extensor torque expressed relative to body weight was significantly greater in sprinters than in long distance runners (Table 2).

Table 3 shows the means and standard deviations for the hamstring/quadriceps strength ratios in both groups. The right hamstring/quadricep ratio did not differ significantly in the two groups. The left hamstring/quadricep ratio was significantly higher in sprinters than in long distance runners ($p < 0{,}05$).

The means and standard deviations of peak torque values for the dominant and non dominant quadriceps and ham-

Table 1: Means and standard deviations for age, weight and performance in long distance runners and sprinters.

	Age (Years)	Weight (kg)	Best Performance
Long Distance Runners	26,24±0.70	66,90±10	42km : 158 min 21km : 74 min
Sprinters	22,00±0,90	70,82±1,84	200m : 21,8±0,15 sec 100m : 10,7±0,05 sec

Table 2: Means (± sD) of peak torque (ft lbs) and peak torque/kg body weight for quadriceps and hamstrings of right and left legs

Group	Muscle Group	Peak Torque (ft lbs) Right Leg	Peak Torque (ft lbs) Left Leg	Peak Torque/kg (ft lbs/kg) Right Leg	Peak Torque/kg (ft lbs/kg) Left Leg
Sprinters (n = 21)	Quadriceps	170.24±7.10	169.71±6.74	2.4±0.07	2.40±0.08
	Hamstrings	106.33±4.50	105.57±4.98	1.49±0.04	1,48±0.05
Long Dist Runners (n = 25	Quadriceps	139.64±3.26	140.12±3.82	2.08±0.05	2.11±0.06
	Hamstrings	85.4 ±2.26	80.00±2.81	1.28±0.03	120±0.04

strings muscle groups are presented in Table 4. No significant differences in peak torque of the hamstrings and quadriceps and therefore in strength ratios (Table 5) between the dominant and nondominant leg for sprinters were found. In long distance runners, the dominant hamstrings were significantly stronger than the nondominant hamstrings but the quadriceps did not differ significantly. This resulted in the dominant leg creating a significantly higher flexor/extensor ratio, compared with the non dominant leg (Table 5) in long distance runners.

The relationship of total body weight to right and left quadriceps muscle torque in sprinters was significant ($r = 0,77$ and $r = 0.60$ respectively). There was a significant correlation between right and left hamstring torque and body weight in sprinters ($r = 0.75$; $r = 0.60$). In long distance runners, a significant correlation of body weight and peak hamstring muscle torque on the right leg was found ($r = 0.63$). Nor other significant correlations of muscle torque with body weight were found in long distance runners.

Hamstring / quadriceps muscle strength ratios were not significant correlated with body weight in either groups of runners ($p < 0.05$).

Table 3: Means (±sD) of the hamstring/quadriceps ratio for left and right legs

Group	Ratio of Mean Right Leg	Peak Torque Left Leg
Sprinters	62.91 ± 1.68	62.14 ± 1.68
Long Dist Runners	61.32 ± 1.37	57.28 ± 1.42

Table 4: Means (±sD) of the dominant and non dominant hamstring and quadriceps

Group	Muscle Peak Torque (ft lbs) Group	Dominant Leg	Non dominant Leg
Sprinters	Quadriceps	171.33±6.78	163.62±7.05
	Hamstrings	107.33±4.43	104.57±5.00
Long Dist Runners	Quadriceps	140.32±3.44	139.44±3.66
	Hamstrings	85.56±2.32	79.80±2.71

Table 5: Means (±sD) of the hamstring/quadriceps ratio for the dominant and non dominant legs

Group	Ratio of Peak Torque (Hamstring/Quadriceps) Dominant Leg	Non dominant Leg
Sprinters	62.99 ± 1.66	62.05 ± 1.70
Long Dist Runners	61.16 ± 1.34	57.44 ± 1.47

86% of sprinters are right leg dominant, 14% are left leg dominant.
84% of long distance runners are right leg dominant, 16% are left leg dominant.

DISCUSSION

The athletes used in this study were tested during the competitive period of the running season. They were well trained and in excellent physical condition with no knee condition or thigh muscle strain for at least a 3 month period prior to the study. Their injury history indicated a low incidence of injury over the past year and no participants had any muscle imbalance predisposing them to injury.

Isokinetic Strength

No significant age related differences in isokinetic strength were found from an analysis of variance test in either groups of subjects. This is in contrast to other investigators who have found significant increases in hamstring and quadriceps muscle strength with increasing age.[10,21,23,24,29] However, this may have been the result of different age ranges. Murray (26), for example, found younger men (age 20-35 years) to be significantly stronger than older men (45-65 years), however, quadriceps muscle strength was assessed isometrically, not isokinetically.

Sprinters had significantly stronger quadriceps and hamstrings than long distance runners. The mean peak torque values of the quadriceps and hamstrings in long distance runners (139.64 ± 3.26 and 85.4 ± 2.26 ftlbs or 189.35 ± 4.42 and 115.80 ± 3.07 Nm) is similar to that found by Morris (25) *et al* in distance runners tested at the same speed (i.e. 132.6 ± 16.59 and 86.7 ± 12.91 ftlbs or 179.81 ± 22.50 and 117.57 ±17.51 Nm). Gilliam [10] *et al* reported similar quadriceps and hamstrings torque values in football linemen to those values obtained by sprinters in this study. The difference in strength observed in sprinters and long distance runners tested at the same speed may be related to muscle fibre composition. Studies have shown a predominance of slow twitch muscle fibres of endurance athletes and a high proportion of fast twitch muscle fibres in sprint athletes.[5,6,12,34] Fast twitch fibres are important for force output during fast contractions which are required for sprinting.[34] However, Thorstenson[34] *et al* found that high torque values were attained by track athletes with a low proportion of fast twitch fibres, and thus there is no conclusive evidence that performance can be predicted on the distribution of fibres in the muscles.

Hamstring/Quadriceps Strength Ratios

Values obtained for hamstring/quadriceps strength ratios have been reported in the literature.[27] The ratios obtained in this study agree with those reported by other authors. Holmes[12] *et al* found flexor/extensor ratios of 0.58 in male high school students for the dominant leg. In a study of high school football players, ratios of 0.56 at 54 degrees/sec were obtained.[29] Morris[25] *et al* found hamstring/quadriceps strength ratios in collegiate middle distance runners to be similar at low speeds (0.63 at 30 degrees/sec and 0.65 at 60 degrees/sec). Scudder [31] reported hamstrings to be 60% of quadriceps irrespective of the speed of testing. It has been suggested that keeping the torque output of the hamstrings 60% of the quadriceps minimizes the extraordinary amounts of stress on the knee. Goslin and Charteris [13] suggested a deviation in the hamstring/quadriceps strength ratio from 1 : 2.25 would increase the risk of injury. However, the study included male and female non athletes.

Studies which have shown a different strength ratio have involved different populations. Wyatt[35] reported higher ratios for men than for women tested at 60 degrees/sec. Earlier studies reported ratios of 0.5, however the subjects of such studies did not involve athletes.[17,22] Gilliam[10] *et al* found football players to have a flexor/extensor strength ratio of 0.6.

Thus it would appear that flexor/extensor strength ratios may be specific for different sports or for different levels of skill required in sport. Ratios of 0.62 for sprinters and 0.59 for long distance runners may indicate a normal flexor/extensor balance for these athletes. Future research should be conducted on athletes in different sports.

Body Weight and Peak Muscle Torque Output

A relationship between total body weight and peak quadriceps and hamstring muscle torque output has been previously demonstrated.[10,29,1,18] The data from the present study also produced significant correlations between peak quadriceps and hamstring strength and body weight for sprinters and between right hamstrings for long distance runners. When torque values were expressed relative to body weight, sprinters showed significantly higher peak quadriceps and hamstring strength values than long distance runners. This finding contradicts that of Housh[19] who found little differences in strength between female track and field athletes when flexor and extensor torque was expressed relative to body weight. Similarly no difference in strength between male and female alpine skiers was found when strength was expressed relative to lean body weight.[15]

The differences in strength between the two groups of runners, having standardized strength relative to body weight, may be due to factors other than weight differences such as differences in training. Whereas sprinters emphasize strength, speed and power training, long distance runners concentrate more on endurance training with only some strength training. In addition, a training history obtained from the runners indicated that 86% of sprinters participated in weight training 2-3 times a week whereas only 20% of long distance runners took part in weight training. Thus apart from the differing training regimes in the two types of athletes, a sprinters thus participated in isotonic strength training which results in muscle hypertrophy.

Dominant and Non dominant Leg Strength

The long distance runners dominant and nondominant hamstring muscle strength differed significantly resulting in dissimilar strength ratios. Although no difference between the dominant and non dominant quadriceps or hamstring muscle strength was found in sprinters, Stafford[32] *et al* found differences in quadriceps muscle strength in football players who have similar strength to the sprinting population. Although the present study did not find this, quadriceps may play a more important role in the training activities of sprinting related sports whereas the hamstrings may play a more important role in long distance running. It may be suggested that more emphasis should be given on conditioning the non dominant hamstrings in long distance runners, however, there is no conclusive evidence of this.

The results obtained in a comparison of left and right legs and of dominant and nondominant legs indicate the left hamstrings and non dominant hamstrings of long distance runners to be significantly weaker than the right and dominant hamstrings. The similarity in these results is probably the result of there being an 86% right leg dominance in long distance runners.

CONCLUSIONS

This study demonstrated the following:

- Hamstrings are approximately 60% of quadriceps torque at a speed of 60 degrees/sec in runners.
- Significant differences in quadriceps and hamstrings muscle strength between sprinters and long distance runners.
- Significant correlation between body weight and peak quadriceps and hamstring muscle torque in sprinters.
- Significant differences in dominant and non dominant quadriceps and hamstring muscle strength in long distance runners but not in sprinters.
- No significant age related effect on peak muscular torque.

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