EDITORIAL

Nineteen ninety five will be remembered as the year in which South African sport finally emerged from isolation to regain international respect. The victory of the Springbok team in the Rugby World Cup final on Saturday June 24th restored an uncertain national sporting pride and was, just perhaps, the greatest single achievement in the history of South African sport. Correctly, much has been made of the importance of that victory for the unification of our fledging nation. But for sport and especially the sports sciences and sports medicine, the long-term effects of that victory hold equivalent potential. Indeed that single victory may yet revolutionize South African sport and help to propel it, at first grudgingly and reluctantly, into the 21st century.

Too little has been made of the significant contribution made by members of our Association to that historic victory. In a soon-to-be released book analysing the basis for the South African victory, former Springbok rugby captain and 1995 World Cup manager, Morne du Plessis, pays special tribute to the medical team that supported the Springboks – team physician Dr Frans Verster, team physiotherapist Evan Speechley and applied kinesiologist Ron Holder. In the developing tradition of South African sports medicine teams, this group "gave unselfishly of their time and expertise, sparing nothing in the support of their team". To their contribution and example must be added those of the large number of physiotherapists, biokineticians, psychologists, doctors, sports scientists and other colleagues who week after week during an increasingly long winter season, have ministered to the medical, mental, spiritual and psychological well-being and have maintained and improved the physical condition of all our provincial rugby stars, who are the fountainhead on which the success of our national rugby team was based.

By helping to make that victory a reality, the abiding contribution of those colleagues will be to hasten the acceptance of sports medicine and the sports sciences as a crucial component of international sporting success by both the general public and those less innovative sports administrators. Indeed since the Rugby World Cup victory, the United Cricket board of South Africa has increased the number of sports medicine professionals, contracted on either a part- or full-time basis from 2 (physiotherapist and exercise specialist) to 5 (dietician, podiatrist and psychologist).

A visiting sports orthopaedic surgeon who works with a number of professional teams in the Southern United States, remarked recently that sports medicine in this country stands on the brink of a revolution similar to that which launched sports medicine in the United States 25 years ago. And the common ingredient is a compelling national interest in sport and the growth of professional sport. What South Africa has, in addition, is the desire of at least three sports (rugby, cricket and to a lesser extent, soccer) to be the leading South African sport and competitive with the best in the world. Such desire will engender a healthy rivalry between those sports as each pushes the other to be more creative and innovative in the quest to capture the imagination of the South African public. Such rivalry promises much to those professions and professionals who can assist in the achievement of the ultimate goals of those sports. And few professions have more to offer than sports medicine and the sports sciences.

So we stand at the start of what will prove to be the most exciting period ever in South African sport. We must grab the opportunities that present themselves and so insure the future of both sport and our profession in the new nation. And, just perhaps, the very future of the nation itself. To make the most of those opportunities we must continue to increase our professionalism in both our scientific research and in the service that we provide to our athletes.

Surprisingly, this Journal will continue to be one crucial measure of how far we are progressing. It will tell us whether we are achieving world class standards in both those areas. It will also measure the extent to which we have overcome the greatest threats to our future success which are to allay historical divisions and suspicions and to join all those involved in sports medicine and the sports sciences into one unified body with a common goal of service (above self) in the interests of South African sport and all her athletes. When we can finally harness the abilities of all our professionals in sports medicine and the sports sciences to that common goal, only then will we be able to call ourselves and our Journal, world-class.

This issue of the Journal covers two areas of importance to our future capacity to serve South African sport.

Dr John Hawley contributes 2 articles on applied physiology. In "Power systems: Implications for high-intensity swim training", he reviews the contribution of the different metabolic systems to the energy used during exercise of different durations and dispels some of the myths on which current swimming training regimes are based. This information is of value in the education both of ourselves but also of our swim coaches, some of whom might perhaps question whether their current training programmes provide the optimal physiological stimuli necessary to develop superior swimming performance. For example, he makes the point that "it is difficult to understand how training for such prolonged periods at speeds which are markedly slower than planned race pace, prepares the swimmer for supra-maximal competitive efforts".

His second article provides state-of-the-art training guidelines for endurance performance. He makes the valuable point that "... during the past century, exercise physiologists can claim to have had only a very limited impact on the training practices of successful athletes with the empirical field-based observations precipitating the majority of breakthroughs in the training patterns of top sports persons". South African scientists should respond to this challenge by making their own contributions to this knowledge.

Both articles show how a knowledge of exercise physiology aids in the development of correct training methods.

If we are to improve the performances of our athletes in international competition, we also need more informa-

(Continued on page 12)

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Power systems: Implications for high-intensity swim training

JA Hawley, PhD, FACSM

Introduction

Many coaches steadfastly believe that improvements in performance are directly related to the volume of work performed during training, and that a swimmer can only reach her/his full potential by undertaking extremely long and arduous training sessions. Competitive swimmers, for example, often train between two and four hours each day swimming up to 20,000 metres, with an energy expenditure exceeding 4,500 kcal/day. As the majority of competitive swimming events last less than five minutes, it is difficult to understand how training for such prolonged periods at speeds which are markedly slower than planned race pace prepares the swimmer for supra maximal competitive efforts (Costill et al 1991).

A swimmer's speed and ability to resist fatigue during training and competition depend on the muscles ability to produce mechanical work (force) from the breakdown of stored chemical energy (mainly carbohydrate and fat). This article describes the different metabolic power systems that provide the energy for muscular contraction, examines the contribution of these systems to the energy requirements of maximal exercise, and details the best type of workouts to train those systems.

Power systems

When describing the physiological entities that produce the energy required to sustain all cellular processes, including muscular contraction, most texts of exercise physiology, and almost all coaching manuals, use the term "energy systems". However, as the primary function of such systems is to produce power for exercise, such terminology seems inappropriate: it would seem conceptually more correct to call them power systems (Hawley & Hopkins, 1995).

The distinction between energy and power systems is not merely semantic: the output of a physiological system should be quantified as the power that can be produced, and not merely the amount of energy potentially available for muscular work. Obese individuals, for example, have vast reserves of energy stored in the form of fat, but are not renowned for their ability to sustain high power outputs!

The body has four distinct power systems it can use to supply energy for exercise: two anaerobic (oxygen-independent), and two aerobic. The names of the power systems represent descriptive summaries of the complex biochemical pathways each uses to produce energy for muscular contraction. These systems are considered distinct by exercise scientists because (1) they have substantially different biochemical pathways, (2) their relative contributions to the energy required for exercise depends on the intensity (speed) and duration of an event, and (3) these contributions can be modified by appropriate training and dietary interventions. It should be noted that for most Olympic swimming events, two, or at the very most three power systems are utilised.

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THE ATP-CP (PHOSPHAGEN) SYSTEM

The phosphagen system uses adenosine triphosphate (ATP) and creatine phosphate (CP) stored within the muscle to provide energy for maximal bouts of strength and speed that last for up to six seconds (Gaitanos, et al 1993). ATP and CP are stored at the contractile site of the muscle, making this anaerobic power system the most readily available for use during high-intensity exercise. The amount of ATP and CP stored within skeletal muscle is, however, quite low and the phosphagen system can only power bursts of maximal exercise for very short periods. Indeed, after only a few seconds of exhaustive work, the power produced by the ATP-CP system decays, so that after six seconds it provides only half of the total energy requirements of exercise (Figure 1). The ATP-CP power system would be used for the start and the initial seconds of a 50 m sprint.

THE ANAEROBIC (OXYGEN-INDEPENDENT) GLYCOLYTIC SYSTEM

This system derives its name from the biochemical pathway that produces energy from the breakdown of carbohydrates without the use of oxygen. This power system is rapidly activated at the onset of intense work, so that even during a six second maximal sprint, the contribution to the total energy requirements of exercise from anaerobic glycolysis reaches almost 50% (Figure 1). In a sprint event lasting approximately 30 seconds, the contribution from anaerobic glycolysis to the total energy requirements of exercise increases to 60% (Medbo and Tabata 1989) (Figure 1). As would be expected, the longer the exercise duration (or the slower the swim speed), the smaller is the contribution to muscle metabolism from the anaerobic glycolytic system. Thus, after a maximal effort lasting one minute, anaerobic energy release has decreased to 50% of overall metabolism, and after two minutes of high-intensity work, to around 35% (Medbo and Tabata 1989) (Figure 1). Associated with the anaerobic release of energy from carbohydrate is the production of lactic acid by the working muscles. Therefore, workouts that develop the swimmer's ability to produce and tolerate high concentrations of lactate are essential for the successful sprinter.

THE AEROBIC GLYCOLYTIC AND AEROBIC LIPOLYTIC POWER SYSTEMS

The two aerobic power systems are named for the fact that they generate energy for muscle contraction from the breakdown of carbohydrate and fats in the presence

Figure 1. *The contributions of the different power systems to the total energy requirements of maximal exercise.*

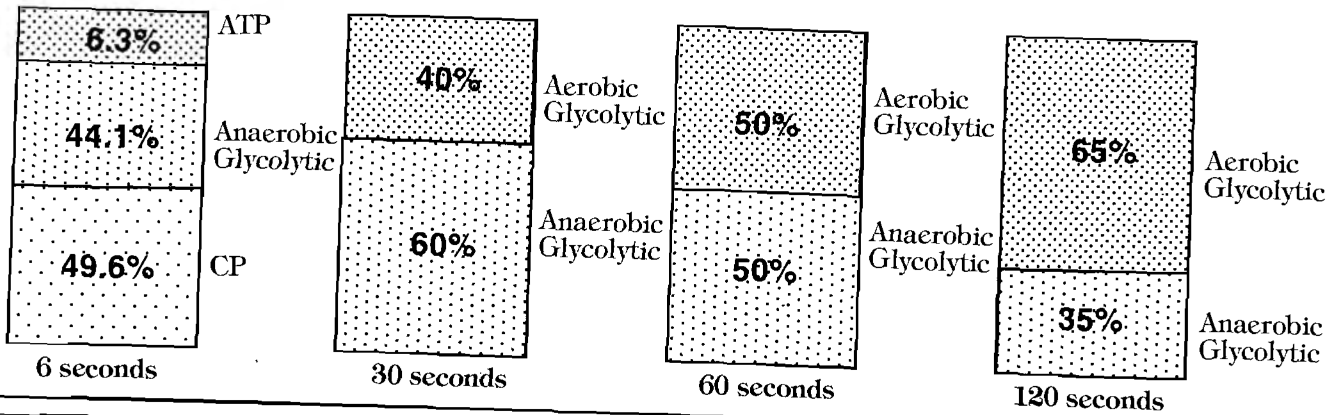

TABLE 1. *The power systems used during high-intensity exercise and the workouts that best train those systems*

Event duration	Major power systems utilised	Main fuel substrates	Training objective and Best type of workouts
< 6 sec	Phosphagen	ATP-CP	*Development of explosive power* Sprint starts Strength training (3 sets of <4 repetitions @ 95% of 1RM) Maximal sprints (<25 m) with complete recovery
< 30 sec	Phosphagen Anaerobic glycolytic	ATP-CP Muscle glycogen	*Lactate tolerance* Sprint repetitions (<30 sec) with long (3-5 min) rest intervals Strength training (3 sets of <8 repetitions @ 85% of 1RM)
<15 min	Aerobic glycolytic	Muscle glycogen Blood glucose	*Development of aerobic power* Maximal-steady-state repetitions (1-5 min) with short (<60 sec) rest intervals
>15 min	Aerobic glycolytic Aerobic lipolytic	Muscle glycogen Blood glucose Intra & extra-muscular fat	*Development of aerobic endurance* Long repetitions (>5 min) with short (<60 sec) rest intervals. Continuous swimming at best steady-state aerobic pace

of oxygen. Intense exercise lasting longer than two minutes and up to three hours is powered predominantly by the aerobic glycolytic system. For longer, less intense exercise, and all ultra-endurance swimming events, the oxidation of fat via the aerobic lipolytic system provides most of the energy for muscle metabolism. Note that fat can only be oxidised in the presence of oxygen.

The duration of maximal exercise for which equal contributions to energy metabolism are made by the aerobic glycolytic and aerobic lipolytic power systems is probably four to five hours (Hawley & Hopkins, 1995). During such prolonged endurance events, the use of fat relative to carbohydrate increases as the intensity of exercise decreases (Brooks and Mercier, 1994). Although both carbohydrates and fats are likely to be used as fuels by the muscle during prolonged endurance training, competitive swim events are powered almost exclusively by carbohydrate, stored in the muscle as glycogen (Costill et al, 1988).

IMPLICATIONS FOR TRAINING

When planning a year-round training programme for the competitive swimmer, the specific physiological demands of the athlete's speciality event(s) should be identified and appropriate training techniques employed that will enhance those factors that are critical determinants of performance. It should always be remembered that the physiological adaptations to training are closely related to the speed, distance and mode of training performed during repeated days of exercise. Since there is little cross-training effect from one power systems to another, or from one type of exercise to another, workouts should be structured to develop those power systems required for the swimmers speciality events (Table 1).

A knowledge of the time course of the power systems utilised during high-intensity swimming events, coupled with the need for specificity in training should assist coaches in assessing whether their current training regimens provide the optimal physiological stimuli necessary for superior swimming performance.

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State of the art training guidelines for endurance performance

JA Hawley, PhD, FACSM

Introduction and background

The purpose of this article is (1) to identify the physiological factors associated with successful endurance performance and (2) provide training guidelines and specific workouts for athletes competing in strenuous events such as cycling (40 km time-trial and over), distance running (5 km and longer), the standard-distance triathlon, and distance-swimming races. Wherever possible scientific studies have been cited to support the physiological rationale underlying specific training principles. In addition the practical experience of the author as a competitive athlete, coach and exercise physiologist involved in the testing, monitoring and prescription of training to elite athletes in several continents during the past decade has been drawn on.

It should be noted at the outset that despite their best efforts, it has proved extremely difficult for sports scientists to manipulate the training regimens of elite endurance athletes for the purpose of scientific inquiry. Thus, during the past century, exercise physiologists can claim to have had only a very limited impact on the training practices of successful athletes, with the empirical field-based observations of coaches precipitating the majority of breakthroughs in the training patterns of top sportspersons (Wells and Pate 1988). Nevertheless, many scientific investigations have consistently identified the physiological variables that are positively related to successful endurance performance. These variables are defined and briefly discussed. The extent to which these and other factors are "trainable" as opposed to genetically determined is a topic of considerable debate (Bouchard et al. 1992). The reader is referred to the excellent reviews of Holloszy et al. (1977) and Saltin (1969) for more detailed discussions of the physiological adaptations to chronic endurance training.

PHYSIOLOGICAL FACTORS RELATED TO SUCCESSFUL ENDURANCE PERFORMANCE

1. Maximal oxygen uptake

Maximal oxygen uptake (VO_{2max}) is the greatest rate at which oxygen can be consumed by an athlete during exercise and, under steady-state conditions, is a reflection of an individuals maximum rate of aerobic energy utilisation (Astrand and Rodahl 1977; Costill 1986; Rowell 1986; Saltin and Astrand 1967; Wilmore 1984). Studies performed over fifty years ago established that oxygen uptake (VO_2) increased with running (Herbst 1928; Liljestrand and Stenstrom 1920b) and swimming speed (Liljestrand and Stenstrom 1920a) and that the fastest athletes had the highest oxygen uptakes (Herbst 1928; Robinson et al. 1937). Over the next fifty years credibility was given to the belief that VO_{2max} was a good predictor of athletic potential in endurance sports (Costill and Winrow 1970a; Costill et al. 1973; Davies and Thompson 1979; Leary and Wyndham 1965; Wyndham et al. 1969). Judging by the frequency with which the topic is discussed amongst athletes and coaches, it would still appear that the vast majority of runners, cyclists and triathletes implicitly believe that the VO_{2max} is the single best predictor of athletic potential in all endurance events (Noakes 1988).

Although VO_{2max} is a satisfactory predictor of endurance performance in a heterogeneous group of athletes (Costill et al. 1973; Farrell et al. 1979), individuals with similar VO_{2max} values can differ markedly in performance velocity (Costill and Winrow 1970b; Coyle et al. 1988; Daniels 1985; Londeree 1986; Noakes 1988).

TABLE 1: *Maximum oxygen uptake values for some elite endurance runners*

Athlete	VO_{2max} (ml/kg/min)	Best Performance	Reference
Said Aouita	83.0	12:58,39 (5 000 m)	Zur Megede and Hymans (1991)
John Walker	82.0	3:49.08 (1 mile)	Agnew (1976)
Steve Scott	80.1	3:47.69 (1 mile)	Conley et al (1984)
Sebastian Coe	77.0	3:47.33 (1 mile)	Zur Megede and Hymans (1991)
Greta Waitz	73.5	2h:24.54 (marathon)	Peronnet and Thibault (1989)
Peter Snell	72.3	3:54.10 (1 mile)	Carter et al (1967)
Frank Shorter	71.3	2h:10.30 (marathon)	Pollock (1977)
Willie Mtolo	70.3	2h:08.15 (marathon)	Noakes et al (1990)
Derek Clayton	69.7	2h:08.34 (marathon)	Costill et al (1971)

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While VO_{2max} in elite male middle and long-distance runners typically range from 75 to 85 ml/kg/min, with extreme values equal to or exceeding 90 ml/kg/min (Bergh 1978; Conley et al. 1984; Costill 1986; Daniels 1974; Martin et al. 1986; Pollock 1977; Saltin and Astrand 1967), such high values are probably not as critical for athletes participating in prolonged endurance events which last 60 min or longer (Table 1).

2. Fractional utilisation of oxygen uptake

Fractional utilisation refers to the percentage of an athletes VO_{2max} that can be utilised at a specified speed or workrate (i.e. race pace). Top marathon runners (i.e. sub 2 hr 20 min) can sustain ~86% of VO_{2max} for the duration of a race (Costill 1972), whereas slower runners (i.e. 2 hr 45 min up to 3 hr) can sustain only 75-76% of their VO_{2max} for the same distance (Farrell et al. 1979; Wells et al. 1981). In cycling, despite similar VO_{2max} values (i.e. 69 ml/min/kg), elite national class riders are able to sustain 90% of VO_{2max} for the duration of a 40 km time-trial compared to 86% for good provincial (state) riders (Coyle et al. 1991). This greater fractional utilisation of VO_{2max} permits the elite cyclists to ride considerably faster over 40 km compared to the good riders (53:54 min versus 60:00 min, respectively).

Although the physiological basis for this endurance capability is not clearly understood (Peronnet and Thibault 1989), it would appear that the fraction of VO_{2max} that an athlete can sustain for prolonged periods is related to the accumulation of lactic acid in the active muscles (Costill et al. 1973; Farrell et al. 1979; LaFontaine et al. 1981; Sjodin and Jacobs 1981). In endurance-trained athletes, for example, there is little or no increase in blood (and presumable muscle) lactate concentration until an exercise intensity that elicits 70-85% of VO_{2max} (Costill 1986; Costill 1970; Farrell et al. 1979).

3. Peak sustained power output

Recently, both sports physiologists (Hawley and Noakes 1992; Hawley et al. 1992; Morgan et al. 1989; Noakes et al. 1990; Scrimgeour et al. 1986) and coaches (Hellemens 1993) have recognised the importance of peak sustained power output as a predictor of endurance performance. In runners, for example, the peak treadmill velocity that an athlete can achieve during a maximal test has been found to be as good a predictor of endurance performance as any physiological variable currently measured (Morgan et al. 1989; Noakes et al. 1990). It has been proposed that the factors which determine peak sustained muscle power production in short duration, high-intensity events like running the 800-1,500 m might also determine performance in more prolonged endurance events, like the marathon (Noakes 1991). This would explain the field-based observations of coaches like Arthur Lydiard (Lydiard and Gilmour 1978) and Gordon Pirie (Pirie 1961), who claim that those distance runners who are the fastest over the shortest distances will also be the fastest over longer distances (Noakes 1991).

In cycling, the peak sustained power output measured during an incremental cycle test to exhaustion has been shown to be a valid predictor of performance during a 20 km time-trial (Hawley and Noakes 1992). In this regard, Coyle et al. (1991) have observed that elite cyclists (mean time of 53:54 min for 40 km) can sustain average power outputs of 346 Watts (W) for one hr, with the best cyclists (51 min for 40 km) able to sustain a power output of 376 W/hr.

4. Fatigue resistance

Fatigue resistance is the ability of an athlete to resist fatigue (i.e. sustain a high power output/speed) during prolonged exercise, and is related to the contractile properties of skeletal muscle. A major adaptation to chronic endurance training is that the skeletal muscles involved in the activity are more fatigue resistant than prior to training (Fitts 1977). Indeed, a recent study from this laboratory has shown that the superior performances of elite black runners in events from 3,000 m up to the marathon are, in part, due to their superior resistance to fatigue compared to white runners (Coetzer et al. 1993). It may well be that an important component of training (and tapering) is to directly alter skeletal muscle contractility (i.e. muscle power) as originally proposed by Noakes (1988).

5. The anaerobic "lactate" threshold

The speed of movement at which a specific blood lactate concentration (usually 4 mmol/L) is observed. Lactate threshold merely reflects the highest exercise intensity that an athlete can sustain for an extended period without amounts of lactate accumulating that are limiting for performance (Wells and Pate 1988). Although there exists much debate as to the terminology describing the kinetics of lactate accumulation during steady-state exercise (Brooks 1985; Jacobs 1986), there is, regardless of how it is measured and defined, a close relationship between lactate threshold and endurance performance (Coyle et al. 1988, 1991: Sjodin and Svedenhag 1985). In running, for example, endurance training increases the speed at the lactate turnpoint and this change correlates closely with actual improvements in running performance (Tanaka et al. 1984). It is, however, unlikely that there is any relationship between the lactate threshold and a heart-rate deflection point (Kuipers et al. 1988; Ribeiro et al. 1985), as was originally proposed by Conconni et al. (1982).

6. Economy of motion

Economy of motion is the cost (i.e. oxygen uptake) required to produce a specific workrate or speed of movement. The best endurance athletes are usually the most efficient (Conley and Krahenbuhl 1980; Daniels 1974; Noakes 1988). Better economy (i.e. a lower oxygen cost) is advantageous during endurance exercise as it is associated with a slower rate of energy utilisation (i.e. muscle glycogen). If fatigue during prolonged endurance events is associated with the depletion of body fuel stores, then the more efficient athlete will be able to cover a greater distance on the same amount of fuel (Noakes 1991).

Several studies suggest that, for running at least, a major benefit of the high (i.e. greater than 120 km) weekly training distances that elite athletes maintain is a progressive increase in running efficiency (Scrimgeour et al. 1986; Sjodin and Svendenhag 1985). With prolonged endurance training (i.e. 3-4 years experience) runners also tend to decrease the length of their stride at a given velocity, with a concomitant increase in stride frequency (Nelson and Gregor 1986). Elite runners also appear to chose an optimal stride length at which they are most efficient (i.e. at which the oxygen cost is the least) and when forced to take either longer or shorter strides for the same running velocity they require an increased oxygen uptake, thus becoming less efficient (Cavanagh and Williams 1982).

Analogous to the long-slow distance training of runners, top cyclists cover many miles, albeit at relatively fast speeds, at a high cadence (90-120 revolutions/min) in a low gear ratio in order to develop a smooth efficient leg stroke at speed (i.e. spinning). Of interest here are the results of a recent study by Coyle et al. (1992) that showed that among a group of well-trained cyclists, cycling economy at submaximal workrates differed by as much as 15%. Such differences in efficiency were not due to differences in cycling technique but, instead, related to the number of slow-twitch (type I) muscle fibres in the quadriceps muscles of the cyclists; those subjects with a high percentage of type I muscle fibres were more efficient (i.e. required less oxygen) to work at either 50% of 70% of VO_{2max} than subjects with a low percentage of slow-twitch fibres (Coyle et al. 1992).

In swimming, the distance covered with each stroke has been shown to be an excellent predictor of performance for both sprint and distance events (Costill et al. 1985; Hawley et al. 1992). For a given speed, a swimmer who has the greatest stroke-distance is assumed to have the most efficient technique (Costill et al. 1985). Such a technique is assumed to be a direct consequence of the enormous distances covered by most swimmers during training.

7. Fuel utilisation

At high workrates (speeds) there is a greater reliance on carbohydrate than lipid substrate (Bock et al. 1928). Highly-trained endurance athletes can make greater use of fat as a fuel for energy provision during high-intensity submaximal exercise than less trained individuals, thereby conserving muscle and liver glycogen stores. However, the whole concept of training longer and further to increase the muscles ability to utilise fat remains contentious. For example, if an athlete trains more than 60 min/day there is little additional enhancement of the muscles ability to utilise fat as a fuel in preference to carbohydrate (Coyle EF, personal communication).

In summary, the principal physiological requirements of an endurance athlete wishing to compete at a high level during prolonged exercise are: (1) a high but not phenomenal VO_{2max}, (2) the ability to utilise a high percentage of VO_{2max} for sustained periods, (3) the ability to sustain high power outputs and resist muscular fatigue during prolonged exercise, (4) a high power output (or speed) at the lactate threshold, (5) an efficient technique, and (6) the ability to utilise fat as a fuel during sustained exercise at high workrates. Training techniques to promote these physiological adaptations will now be discussed .

TRAINING TECHNIQUES FOR SUCCESSFUL ENDURANCE PERFORMANCE

Since World War II the training practices of elite endurance athletes have passed through several identifiable and distinct phases. These stages can usually be associated with influential coaches of the time (i.e. Franz Stampfl, Percy Cerruty and Arthur Lydiard in running; Forbes Carlile and James Councilman in swimming; Cyrile Guimard and Eddie Borysewicz in cycling), each of whom has been credited with the development of a number of leading athletes. As a result, there currently exists a multitude of diverse training techniques for the performance of prolonged exercise. Elaborate training systems based on multiply macro and micro cycles with specific attention to the periodisation of training have been proposed. However, such programmes are often theoretically based, lack scientific validity, and are of little practical value for the majority of coaches and athletes who must often train all year round to compete successfully on an international level (Hopkins 1993; Horwill 1992).

A common trend in many endurance sports has been for coaches and athletes to adopt and implement the prevailing training regimens of current world-class performers in their discipline. While such a practice has obvious drawbacks and typically results in the downfall of many a promising athlete, this method may, occasionally, contribute to the unprecedented success of an individual. In this regard, it is generally assumed by many coaches and athletes that improvements in performance are directly related to the amount of work performed during training, and that an athlete can only reach his or her full potential by undertaking extremely long and intense training (Costill et al. 1991). Although the volume of exercise is among the variables known to determine the degree of adaptation to training (Davies and Knibbs 1971; Faria 1970; Fox et al. 1973, 1975; Shephard 1968), there is now evidence, at least for swimmers, that such extensive training may not necessarily enhance performance (Costill et al. 1991).

Intuitively the perfect training programme for endurance performance should include elements of all the training techniques currently practiced by todays successful performers. However, most of the key facets that constitute the generic core of a year-round training programme for the endurance athlete can be divided into just three main phases: (1) base or foundation training, (2) transition training, and (3) speed or power training, incorporating a taper phase before a major competitive peak. During each phase of training primary emphasis is given to the development of one (or more) specific physiological objectives (i.e. the development of fatigue resistance, or the improvement of economy of motion etc.).

1. Base/foundation training

Performed during the winter or the non-competitive period of an athletes macrocycle, the primary emphasis of this phase of training is the establishment of a sound aerobic foundation on which to base subsequent (more intense) training (LeMond and Gordis 1990; Lydiard and Gilmore 1978, 1983; Wells and Pate 1988). The physiological benefits ascribed to base/ foundation training include enhancement of myocardial function (Clausen 1977) and oxygen transport (Ekblom 1969), an increase in blood volume (Convertino et al. 1980), enhancement of mitochondrial and oxidative capacity of skeletal muscles (Fink et al. 1977; Kiessling et al. 1971; Saltin 1969) and improved fat mobilisation and utilisation (Gollnick 1985).

In the base/foundation phase of training, the overall training quotient (i.e. duration x intensity x frequency) is kept well below that threshold that would over-extend the athlete and lead to signs of over-reaching, staleness and fatigue (Carlile 1964; Councilman 1968; Hopkins 1993). Base training is typically performed at intensities ranging from 65-70% of VO_{2max} (70-80% of maximum heart-rate) for a minimum of 30 min up to several hr duration each day, with a frequency of between 7-12 sessions/week, for as long as possible (i.e. 3-4 months) depending on the time lag after the athletes last competitive phase. Whether base training in the high volumes currently undertaken by elite runners (140-160 km/week), cyclists (500-800 km/week) and swimmers (50-60 km/week) is essential to elite performance has not been systematically determined. In this respect, it is difficult to explain how training up to 4 hr/day at speeds which are markedly slower than planned competition pace can possibly prepare the elite swimmer for races which typically last less than 15 min. Research is needed to establish whether base training per se results in better endurance performances compared to when the athlete trains at an intensity (or effort) that is more specific to the athletes specialist event from the outset of a training cycle (Hopkins 1993). Whether base/foundation training has any benefit to athletes whose speciality event has no aerobic component remains speculative.

2. Transition training

The second phase of training whose prime objective is to expose the various physiological power systems to sustained exercise at an intensity (or effort) which corresponds to the athletes highest current steady-state pace. The physiological and performance enhancing benefits ascribed to transition training include enhancement of lactate kinetics (MacRae et al. 1992; Tanaka et al. 1984) and stimulation of the specific neurological patterns of muscle fibre recruitment needed during a race (Costill 1986; LeMond and Gordis 1990).

Intermittent (or interval) training has been the cornerstone of swim training for many decades (Carlile 1964; Daniels and Scardina 1984), although it was not until the 1960's that the first sports scientists began to study the effects of different combinations of work and recovery on physiological systems (Astrand et al. 1960; Christensen et al. 1960). Transition training can be performed as continuous steady-state exercise or intermittent work bouts with short rest intervals (Brooks and Fahey 1985; Costill 1986). The intensity of this phase of training should correspond to ~85% of VO_{2max} or 90-95% of the athletes maximal heart-rate, the so called "aerobic-anaerobic threshold" (LeMond and Gordis 1990), or the athletes best current race-pace for either a 10 km (running) a flat 40 km time-trial (cycling/triathlon) or 1,500 m (swimming). Although exercise prescription based on blood lactate concentrations has become popular with swimmers and more recently cyclists for determining the effort of transition training, there is little scientific evidence to support such practices. An example of a transition session for a runner or cyclist would incorporate a thorough 30 min warm-up, followed by 6-8 repetitions each of 5 min duration at the athletes best current race pace for their event, with a maximum of 60 sec active recovery (i.e. jogging or low gear spinning). There is no need to measure the precise distance covered during each work bout; as an athlete gets fitter they will merely cover more distance in a given time. Transition training should be performed twice a week for the four weeks immediately following the base phase. In addition several time-trials over distances less than the athlete's planned competitive event may be undertaken during this time. The athlete should aim to complete such trials at a pre-planned pace or effort, at close to projected race pace, but not necessarily all-out.

3. Speed/power training

The final phase of training which is designed to expose the various physiological systems to maximal or supramaximal exercise at a speed (or efforts) which are faster than planned race-pace. Speed/power training employs relatively high intensity work bouts with long rest periods (Coe and Miller 1981; Moorcroft and Temple 1984). The overall volume of training is low during this final phase. An example of such a session for a runner or cyclist would involve an extended warm-up, followed by 6-8 repetitions of up to 90 seconds duration with a complete (i.e. 5 min) active recovery (i.e. jogging or low gear spinning) between repetitions. Heart-rate monitoring is not a valid technique for determining the intensity of speed/power workouts; often an athlete will attain a higher heart-rate (and blood lactate concentration) after the exercise bout. Speed/power training should be performed up to three times/week during the final 21 days before a major competition. In the final 7-10 days immediately prior to an important race, the training load is gradually reduced to nearly zero. As has been previously stressed (Hopkins 1993), the lower overall workloads in this phase of training are achieved by reducing the volume and frequency of training and not the intensity. Indeed, a recent study (Shepley et al. 1992) found that middle-distance runners significantly improved their performance times by sharply reducing their training volume while maintaining or slightly increasing their training intensity seven days before a race. This method of taper was superior to both a reduction in training intensity, and total rest (i.e. no running at all) in the week prior to competition (Shepley et al. 1992). Practical research is needed in most endurance sports to determine the optimal combinations of reductions in volume and intensity that will subsequently result in the greatest improvements in performance.

When planning a year-round programme for the endurance athlete, the specific physiological demands of the event should be identified and appropriate training techniques employed that will enhance those factors that are critical determinants of performance. It should always be remembered that the physiological adaptations to training are closely related to the speed, distance and mode of training performed during repeated days of exercise. Since there is little cross-training effect from one type of exercise to another (Costill 1986; Wells and Pate 1988), workouts should be structured to develop only the power systems required for the athletes speciality event (Hopkins 1993).

Finally, endurance training is not, and will never be, a purely scientific endeavour. Current knowledge of training practices has evolved mainly through the experiences of many coaches and their charges and not usually because of any scientific breakthroughs arising from laboratory-based investigations by sports scientists with top athletes. Future innovations in training techniques, improvements in athletic performance, and breakthroughs in applied exercise science will only be accomplished as a result of closer working relationships between athletes, coaches and sports scientists who possess a comprehensive and practically based knowledge of specialised events.

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(Continued from page 1)

tion, not only of human exercise physiology but also the specific requirements of different sports. Dr Maurice Mars, himself an international athlete and regular competitor in the 'Duzi and other canoe marathons, has researched the energy cost of portaging the canoe on either the preferred or the weaker shoulder. He shows, not unexpectedly, that portaging the canoe substantially increases the energy cost of running but that the increase is greater when the weaker shoulder is used because there is less control of the movement of the canoe. He concludes that canoeists need to train for portaging and provides a simple calculation to assist canoeists in calculating the running speed they should choose when portaging. His elegant study shows how practical question are open to scientific solution to the benefit of the athletes in that particular sport.

To promote physical activity and sport, we must also research the possible health benefits of regular physical activity. Three colleagues from the University of the Orange Free State have provided a valuable metanalysis review of the effects of exercise on depression. Their analysis suggests that exercise has a significant effect in reducing depression and that this effect is independent of age and health status. This information is particularly valuable for although we usually prescribe exercise for its physical benefits, it may well be that the greater value of regular physical activity may be on our moods and emotions.

I trust that this issue of the Journal will inspire you further in your personal contribution to South African sports medicine and sports science. The 1999 Rugby World Cup is just more than 3 years away. How will each of us contribute to insure that the William Webb Ellis trophy stays in South Africa in the first decade of the next millennium?

Professor Tim Noakes
Professor in the Liberty Life Chair of Exercise and Sports Science

South African Journal of Sports Medicine

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The metabolic demand of portage in kayak marathons

M Mars

Summary

Portage forms an integral part of some long distance kayak races. The metabolic demands of portaging a single person racing kayak were investigated in 15 subjects who regularly participated in kayak marathons. Subjects completed 6 minute treadmill runs at 8 km/hr and at 3% gradient, both unloaded and carrying a 14.1kg kayak. During the portage run, the kayak was transferred from one shoulder to the other after 3 minutes. Kayakers are shown to have a preferred shoulder with which they are more efficient at portage. In comparison with running in the unloaded state, portage of a kayak of this mass on the preferred shoulder increases mean oxygen uptake by. 447 ± 151 $ml.min^{-1}$ and mean heart rate by 15.4 beats/min. On the weaker shoulder, significantly greater increases of both oxygen uptake 590 ± 139$ml.min^{-1}$ ($p<0.01$) and heart rate 20.5 beats/min ($p < 0.05$) occur. The increase in oxygen uptake on the weaker shoulder is ascribed to lack of stability of the kayak during portage and consequent loss of running efficiency caused by balancing manoeuvres. As few kayakers include portage in their training programme, a simple method of estimating optimal portage pace is proposed.

Introduction

Portage is an integral part of long distance canoe and kayak racing. It is defined as, "the carrying of boats or goods between two navigable waters".[1] While portage is usually undertaken over short distances to avoid a dangerous or non navigable part of a river, an overland route cutting across an oxbow may be quicker than staying in the water and paddling. Portage therefore becomes part of race strategy in some long distance river races.

One such race is the Msinduzi canoe marathon. This annual 3 day event from Pietermaritzburg to Durban on approximately 130 km of the Msinduzi and Mgeni rivers in KwaZulu Natal, South Africa, attracts over a 1 000 competitors. The title of the race is misleading as fibreglass racing kayaks and not canoes are used, and because of various gorges, waterfalls, and oxbows in the river, several sections of the race are overland, with portages of up to 10 km being encountered.[2] The ratio of paddling to running is determined by the canoeists' relative skills and the level of the water. In years of drought, low water rules allow competitors to portage almost two thirds of the course.

The energy demands of portage have not been established. It has been shown that the energy requirement of moving a known mass over a fixed distance is not constant, and is dependent on the method of carriage.[3,4,5] Carrying a single person racing kayak on the shoulder while on the run requires learned skills of balance, as one arm is removed from the normal running action and is used to steady the kayak. This may further increase energy expenditure. In addition, most canoeists appear to have a dominant shoulder on which they prefer to portage. This preference may be due to shoulder asymmetry, and be simply a matter of comfort, or it may be the result of a difference in efficiency of carriage between shoulders. Despite favouring one shoulder for portage, the kayak is usually transferred from shoulder to shoulder every two to three minutes on long portages.

While portage potentially forms a major component of the race, training for portage is largely empirical. A 15 time winner of the event proposes two training programmes for portage. For the competitive paddler/runner aiming at winning the race, it is suggested that running with the canoe should be included as part of the running training, and should start 3-4 months before the race. The running programme outlined for the average competitor, however, makes no mention of portage.[2]

It is estimated that 95% of paddlers follow this second option and do not run with a boat on their shoulder in training. A reason for this, is that it is hazardous to run with a 5.2m kayak on one's shoulder on urban roads. The problem encountered by this group is estimation of the optimal pace at which to portage during the race.

The aims of this study were to investigate the energy expenditure of portage, to determine whether the energy requirements of portage are constant on either shoulder and to propose a simple means of predicting a suitable race portage pace, based on pre-race running training.

Method

Fifteen males who regularly compete in kayak marathons, volunteered to take part in this study which was performed 6 weeks prior to the Msinduzi marathon. All tests were performed in the morning and no exercise had been undertaken prior to testing. Each subject gave informed consent and completed a questionnaire detailing his kayaking experience including the number of seasons of competitive participation, his Natal Canoe Union grading and the number of Msinduzi Marathons entered. Their competitive running experience and active participation in other sports was also recorded. Subjects nominated their preferred shoulder of portage before testing.

The subjects were exercised on a motorised treadmill under each of the following four conditions.

1. Running for 6 minutes at 8 km/hr at a 3% gradient.
2. Running for 6 minutes at 8 km/hr at a 3% gradient wearing a backpack loaded to 14.1kg with sand bags.
3. Running for 6 minutes at 8 km/hr at a 3% gradient carrying a single person racing kayak weighing 14.1 kg. The kayak was first carried on the right shoulder and after three minutes, transferred to the left shoulder.
4. Running to exhaustion on a fixed speed, increasing gradient protocol.

Each exercise protocol was followed by a 10 minute recovery period with the subject seated on a chair on

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the treadmill. A balanced order experimental design was used in which 8 subjects wore the backpack first and 8 subjects carried the kayak first.

Oxygen consumption (VO_2) was recorded throughout the four exercise protocols and rest periods and was measured using open circuit computerised spirometry, (Oxycongamma, Myjnhardt). Calibrations were performed before each test. The average readings of the last 30 seconds of each exercise protocol were used for analysis. Heart rate was recorded using a Beckman electrocardiograph coupled to the Oxycon. All tests were carried out in an ambient temperature of 22-24°C.

The treadmill speed of 8 km/hr was chosen after discussion with the subjects, following a pre-test familiarisation practice run. There was consensus that 8 km/hr at a slight incline, represented a comfortable portage pace, and that it was probably close to the average pace maintained by the subjects on a long portage.

Statistical analysis was by analysis of variance, Duncan's multiple range analysis, and paired t-test, where appropriate, with significance taken at the 95% probability level. Descriptive statistics are presented as means and one standard deviation.

Results

The average age of the subjects was 31.5 ± 7.3 years, range 21-42 years. Canoeing experience ranged from 3 to 15 years averaging 8 ± 3.5 years, with an average of 6 completed Msinduzi Marathons. There were 3 A grade paddles, 9 B grade and 3 C grade paddlers. Grading is based on the ratio of the competitors finishing time to that of the race winner. The A grade, comprises those who finish within the winner's time plus 10%, B grade, is between 111% and 125% of the winner's time, and C grade, between 126% and 140% of the winner's time. All but one of the subjects was involved in some form of regular running training, and only one subject included portage in his training.

Twelve subjects indicated that they preferred to portage on their right shoulder. Of these, 10 subjects were right hand dominant. The remaining three subjects were left hand dominant and preferred their left shoulder for portage.

The mean VO_{2max} was 4 218 ± 333ml.min^{-1}, range 3513-4586ml.min^{-1} or 55.7 ± 5.4 ml.kg^{-1}.min^{-1} (45-64 ml.kg^{-1}.min^{-1}), with a mean maximum heart rate of 188 ± 11.2 beats per minute. Oxygen consumption expressed in absolute terms and as a percentage of maximum, and heart rate under the different exercise conditions, is shown in table 1.

Carriage of the additional mass of 14.1kg resulted in increases in oxygen consumption of 434 ± 154 ml.min^{-1} with the backpack and 446 ± 150 ml.min^{-1} and 590 ± 138 ml.min^{-1} with the kayak on the preferred and weaker shoulder respectively. Statistically significant differences in oxygen consumption ($p < 0.01$) and pulse rate ($p < 0.05$) were noted when comparing shoulders during kayak portage. The differences in oxygen consumption and pulse rate between carriage of the backpack and portage on the preferred shoulder were not significant.

When divided according to their canoe union grading based on race performances, A grade subjects had a significantly higher VO_{2max} (62.6 ± 5.0 ml.min^{-1}.kg^{-1}) than those in B (55.0 ± 5.4 ml.min^{-1}.kg^{-1}) $p < 0.05$, and C grade (50.9 ± 10.8 ml.min^{-1}.kg^{-1}) $p < 0.05$. They performed at a significantly lower percentage of their maximum oxygen consumption, than their B and C grade counterparts, in both the loaded and unloaded states, $p < 0.01$ (Table 2).

Running unloaded, the percentage of VO_{2max} utilised did not differ significantly between B and C grades. Under load however, C graders used a significantly greater percentage of their VO_{2max} than B grade subjects $p < 0.05$.

Comparing shoulders, the increase in oxygen uptake expressed as a %VO_{2max} required for portage on the

TABLE 1. *Oxygen consumption in ml and as a percentage of VO_{2max}, and pulse rate in beats per minute, while running in the unloaded state and with the backpack or kayak are expressed as means and one standard deviation (n = 15). The increase in both oxygen consumption and heart rate was significantly higher with portage on the weaker shoulder than on the preferred shoulder $p < 0.05$.*

	VO_{2max} ml.min^{-1}	% VO_{2max} max	Heart rate
Running unloaded	2 537 ± 229	60.6 ± 7.4%	137.5 ± 11.2
Running with backpack	2 971 ± 185	70.9 ± 6.5%	150.2 ± 11.2
Kayak (preferred shoulder)	2 984 ± 201	71.2 ± 7.7%	152.9 ± 13.1
Kayak (weaker shoulder)	3 128 ± 236	74.7 ± 8.5%	158.2 ± 13.1

TABLE 2. *Age, VO_{2max}, and oxygen consumption as a percentage of VO_{2max}, according to grading of paddlers based on their performances in races, expressed as mean and one standard deviation. The A grade paddlers have a significantly higher VO_{2max} than the other grades ($p < 0.05$), and perform at a significantly lower percentage of their VO_{2max} in both the loaded and unloaded states ($p < 0.01$). Under load, the C grade paddles use a significantly greater percentage of their VO_{2max} than B grade paddlers ($p < 0.05$).*

	A Grade (n = 3)	B Grade (n = 9)	C Grade (n = 3)	All (n = 15)
Age (years)	25.7 ± 9.3	30.6 ± 8.9	40.0 ± 3.5	31.5 ± 7.3
VO_{2max} (ml.min^{-1})	4 422 ± 356	4 271 ± 399	3 855 ± 542	4 218 ± 333
VO_{2max} (ml.kg^{-1}.min^{-1})	62.9 ± 3.5	55.0 ± 5.4	51.0 ± 10.8	55.8 ± 5.5
VO_2 as % of VO_{2max}				
unloaded	50.3 ± 7.4%	62.0 ± 7.4%	66.4 ± 6.9%	60.6 ± 7.2
backpack	61.4 ± 5.0%	71.5 ± 5.4%	78.3 ± 8.1%	70.8 ± 6.6
kayak (preferred)	60.8 ± 8.5%	71.7 ± 4.6%	80.2 ± 15.1%	71.2 ± 7.5
kayak (weak)	63.2 ± 5,8%	74.7 ± 6.2%	85.9 ± 13.2%	74.6 ± 8.7

weaker shoulder was significantly greater within the B and C grades $p < 0.05$ and approached significance in the A grade $p = 0.057$. Within each grade, there was no difference in oxygen consumption when carrying the backpack or portaging on the preferred shoulder.

Discussion

The changes in oxygen uptake and heart rate while running with the backpack, are shown to be similar to those observed for portage of a kayak on the preferred shoulder which on average required an increase in oxygen consumption of 10% of VO_{2max}, and a 13-15 beat per minute increase in heart rate. The similarity in the metabolic requirements of backpack carriage and portage on the preferred shoulder suggests that removal of one arm from the normal running style does not on its own significantly influence energy consumption under these conditions of loading.

The demands of portage differed significantly between shoulders, with portage raising heart rate on average 15 beats per minute on the preferred shoulder and 20 beats per minute on the weaker shoulder. The difference may be explained by a description of the changes in portage technique that occurred in all subjects.

On the preferred shoulder the kayak appeared to be "locked" on the shoulder. During the run, the kayak did not bounce, and it's longitudinal axis remained relatively constant with minimal vertical or horizontal drift. The free arm assumed an apparently normal position during the run. On the weaker shoulder, the kayak was less firmly positioned on the shoulder. Bounce on the shoulder was obvious, being both heard and seen. The kayak tended to oscillate from side to side on it's long axis, and the free arm was used in a circumduction motion with the shoulder abducted ± 40°-60°. Stride length and width usually shortened and widened. It would appear that the increase in metabolic rate was due to primarily to corrective balancing manoeuvres.

The percentage increase in oxygen uptake on the weaker shoulder is similar to the findings of Legg et al who investigated the energy requirements of backpack loading and bilateral shoulder carriage. Both heart rate and oxygen uptake were significantly higher for bilateral shoulder carriage, which was attributed to the raised position of the arms causing an extra strain on the cardiovascular system, increased muscular activity of the shoulders and arms, and use of the muscles of the upper body to compensate for lateral bending of the trunk during load carriage.[3]

As might be expected in an endurance sport, the grading based on race performance relates to maximal oxygen uptake, with the different grades each reflecting a 10% difference in relative oxygen consumption during portage at a set pace. The experimental portage pace of 8 km/hr, although chosen by consensus of the subjects, resulted in the C graders performing at 86% VO_{2max}. One subject required 94% VO_{2max} for carriage on his weaker shoulder, a level that exceeded his ventilatory threshold.

How can the data obtained in this study be used to assist those who do not include portage in their training, to select an appropriate race portage pace? Based on the information that portage of an average mass single kayak will increase heart rate by approximately 15-20 beats per minute, the following simple rule of thumb is proposed.

It is suggested that competitors obtain their heart rate at the end of an 8 to 10 km time trial or hard training run. On a subsequent training run, they should monitor their pulse rates at slower running speeds, until they find the pace which maintains the heart rate at 15-20 beats per minute below their heart rate obtained at the end of the time trial. This should represent the appropriate race portage pace. It is not advocated that subsequent running training be undertaken at portage pace, but rather that the competitor learns to gauge the difference between training pace and portage pace. An alternative would be to carry a weighted backpack on training runs.

For those who use portage in their training, performance might be improved by improving the stability of the kayak on the weaker shoulder, thereby reducing unnecessary energy expenditure.

Although regular training of portage is both difficult and hazardous in urban areas it should logically be included in training programmes as a sport specific task, to improve learned motor skills and to provide correct muscle loading at race pace.

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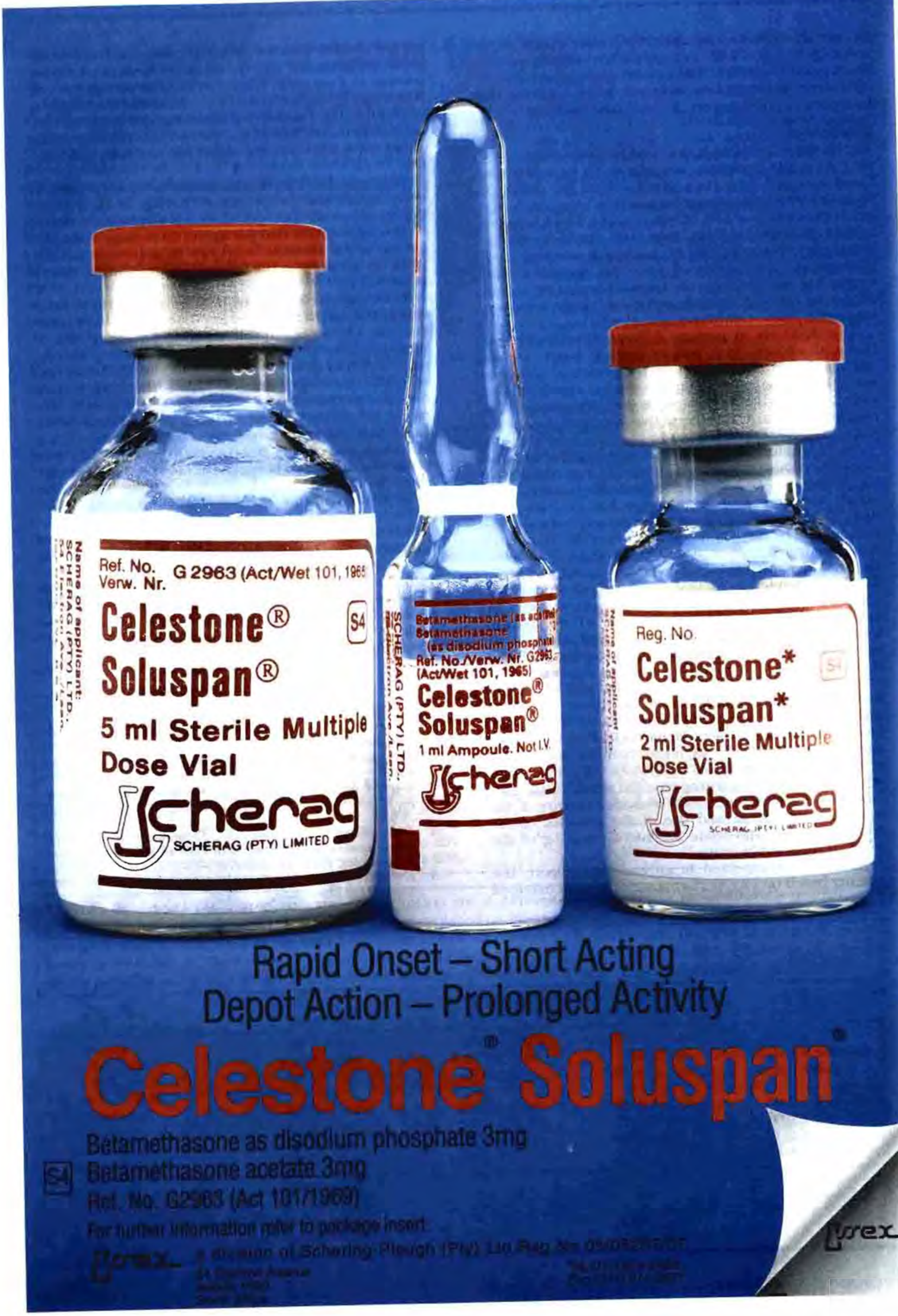

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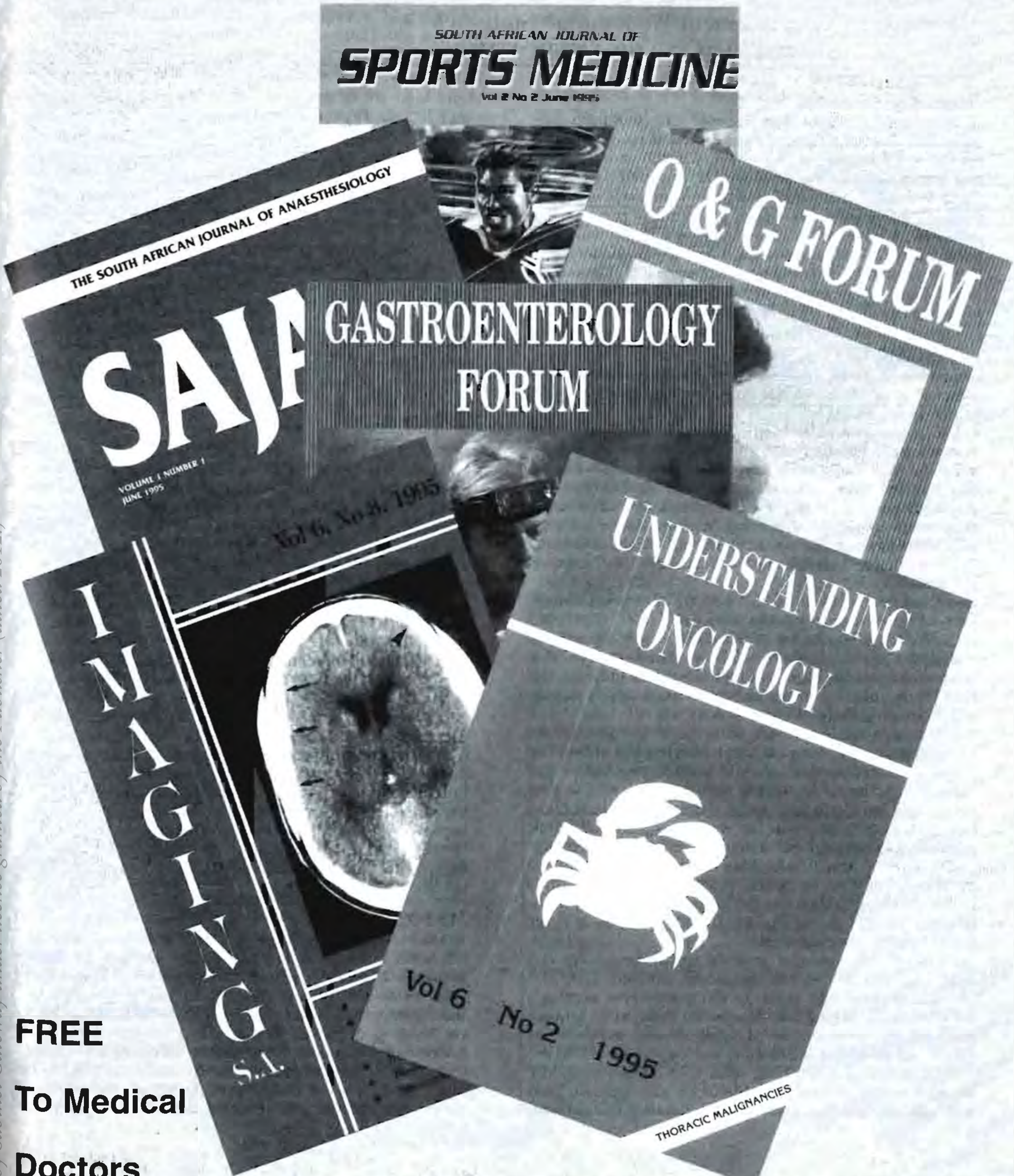

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Die invloed van oefening op depressie: 'n meta-analise

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Abstract

A meta-analysis was done on the existing literature regarding the influence of exercise on depression. The results of 40 studies, with a total of 3 225 experimental subjects were coded by means of 12 research questions. The effect sizes were calculated and the statistical significance of the results was tested by means of an ANOVA analysis. A mean of 94 effect sizes were found with a z-value of -6,736. This indicates a highly significant (p < 0,001) reduction in depression with exercise. It was also found that neither gender nor the health status nor age play any role in the effect of exercise on depression.

Inleiding

Depressie kan vandag met reg beskou word as 'n wesenlike probleem in die samelewing en wel om die volgende redes:

- Dit is 'n gesondheidsprobleem vanweë die hoë voorkomssyfer daarvan.[1]
- Dit is ook 'n sosio-ekonomiese probleem vanweë behandelingsmetodes wat hoofsaaklik bestaan uit medikasie, psigoterapie en hospitalisasie of 'n kombinasie van al drie. Dit bring 'n ekonomiese las mee en dikwels ook die onttrekking uit die gemeenskap en werksomstandighede wat verlies aan manure beteken.[2]

Depressie is so algemeen dat 15% tot 20% van alle volwassenes op enige tydstip simptome van depressie ondervind. By minstens 12% sal depressie op een of ander tydstip in hulle lewens so ernstig wees dat behandeling nodig sal wees, terwyl volgens skatting dit vir 75% van hierdie groep nodig sal wees om in psigiatriese hospitale opgeneem te word.[1]

Die waarde van oefening as metode in die kliniese evaluering, voorkoming en rehabilitering van siektetoestande, het eers gedurende die sestigerjare vanuit die verskillende navorsingsvelde aandag verkry.[3] Dit was egter eers in die laaste twee dekades dat navorsers belangstelling begin toon het in die psigologiese effek van oefening en veral die invloed daarvan op depressie.[2]

Die invloed wat oefening op depressie het, word al meer en meer deur navorsers in verskeie vakdissiplines in die soeklig geplaas. Die bevindinge wat deur verskillende navorsers in die literatuur opgeteken is, is egter dikwels nie versoenbaar nie.

In sommige van die studies word aangetoon dat oefening wel 'n antidepressiewe invloed het.[2,4,5,6,7] Hierdie invloed kan selfs op indirekte wyse meehelp tot die vermindering van depressie. Daar word beweer dat oefening soos draf ook as psigoterapie gebruik sou kon word in die behandeling van depressie.[6] Hierdie outeur motiveer sy stelling soos volg: Draf los nie die persoon se eksistensiële probleme op nie, maar dit bied wel tydelike verligting wat aan die persoon die geleentheid bied om sy probleme op te los (soortgelyk aan 'n aspirien vir die verligting van hoofpyn). Ander studies toon geen betekenisvolle invloed van oefening op depressie aan nie.[8,9] Hierdie teenstrydigheid in navorsingsresultate kan waarskynlik aan twee oorsake toegeskryf word:

- Oefening word nie duidelik gekwalifiseer en gekwantifiseer nie.
- Heelwat navorsers gebruik die tradisionele verhalende metode van navorsing wat soms lei tot subjektiewe interpretasies en afleidings.

Die breë doel van hierdie studie was om, met behulp van meta-analise, 'n deeglik verantwoorde statistiese integrering van resente navorsingsresultate oor die invloed van oefening op depressie te maak. Om verder die rol wat sekere geïdentifiseerde veranderlikes met betrekking tot die invloed van oefening op depressie speel, na te gaan.

META-ANALISE

Meta-analise het 'n kwantitatiewe aanslag op navorsing en maak gebruik van 'n verskeidenheid statistiese tegnieke vir die selektering, klassifisering en samevatting van inligting wat verkry is uit verskeie empiriese studies. Daar bestaan 'n hele aantal tegnieke wat algemeen aanvaar word en waarmee verskillende tipes statistiese gegewens vanuit verskillende empiriese ondersoeke na een maatstaf, die sogenaamde effekgrootte (effect size), herlei kan word. Die metode wat gebruik word in die berekening van die effekgrootte, is afhanklik van die tipe statistiek soos gerapporteer in elke studie wat by die meta-analise betrek word. Tegniese probleme word soms ondervind in die samevoeging van resultate van eksperimentele studies. Die rede hiervoor kan moontlik wees dat statistiese toetse nie altyd die sterkte van die verwantskap of die effek van belang aantoon nie en daarom beveel navorsers[10,11,12] aan dat resultate gekombineer moet word, met aanduiding van effekgrootte. In hierdie studie is van verskillende outeurs[11,12] se formules gebruik gemaak om die effekgrootte te bereken. Beskrywende statistiek word gebruik om die navorsingsresultate te kondenseer, op te som en vereenvoudig tot 'n enkele resultaat.

METODE

'n Literatuursoektog is geloods met behulp van geïdentifiseerde sleutelwoorde (oefening/exercise; fiksheid/physical fitness; draf/jog; depressie/depression; gemoed/mood; angs/anxiety) wat met behulp van rekenaarsoektogte op die volgende databasisse, Psychoinfo en Mesh gemaak is. Tydens die vooronderosoek is 'n kodeervorm ontwikkel en verfyn; dit vorm die sleutel tot sukses in meta-analise. In die verwerking van die algehele data is die z-toets gebruik om vas te stel of die totale gemiddelde effekgrootte van depressie betekenisvol verskil van nul. As 'n gemiddelde effekgrootte in hierdie studie betekenisvol verskil van nul, word die nulhipotese van geen effek verwerp. 'n Waarskynlikheidspeil van ($p < 0,05$) is gebruik om te bepaal of die analise statisties betekenisvol is, al dan nie.

Die veranderlikes word met behulp van beskrywende statistiek weergegee in die vorm van tabelle vir die verskillende kategorieë van die geanaliseerde veranderlikes en sluit die volgende in: die aantal effekgroottes in die onderskeie kategorieë, die gemiddeld en standaardafwyking van die betrokke effekgroottes, asook die z-waardes onderskeidelik. Die Pearson-produkmomentkorrelasie, asook eenrigting ANOVA's is gebruik in die verwerking van gegewens.

RESULTATE

'n Totaal van 40 studies is gebruik om 94 effekgroottes van depressie te bereken. Die totale aantal proefpersone wat betrek is, is 3 225 (eksperimentele, kontrole en vergelykende groepe).

Die beskrywende statistiek met betrekking tot die invloed van oefening op depressie word in tabel 1 aangedui.

Die gemiddeld van die 94 effekgrootte oor die invloed van oefening op depressie is -0,5907, met 'n z-waarde van -6,736, wat hoogs betekenisvol ($p < 0,001$) is en aandui dat die eksperimentele groep wat oefening gedoen het, betekenisvol van die kontrolegroep verskil en 'n laer gemiddelde depressietelling het. Uit die resultate kan dus gekonstateer word dat oefening 'n verlagende invloed op depressie het. Hierdie resultaat korreleer met dié van vorige navorsers[2,13,14,15,16,17,18] dat oefening 'n antidepressiewe effek het. Daar bestaan ook 'n negatiewe korrelasie ($r = -0,6672$) tussen depressie en fiksheid wat hoogs betekenisvol is ($p < 0,01$). 'n Negatiewe korrelasie dui daarop dat namate die proefpersone fikser geword het, hulle minder depressief was. Om te bepaal watter proefpersoon-populasie die meeste baat gevind het by oefening in die verlaging van depressie, is vier veranderlikes aangespreek, naamlik ouderdom, geslag, gesondheidstoestand en die depressie van die proefpersone.

TABEL 1
BESKRYWENDE STATISTIEK VAN DEPRESSIE TEN OPSIGTE VAN DIE TOTALE GROEP

Totale groep	Aantal effekgroottes	$\bar{x}$	Sigma	z-waarde
Totale data	94	-0,5907	0,8502	-6,736*

* $p < 0,001$

Ouderdom

Ouderdomskategorieë is ingesluit omdat baie van die gekodeerde studies nie die gemiddelde ouderdom van proefpersone aangegee het nie, maar tog genoegsame inligting verskaf het om die proefpersone volgens ouderdomme in die verskillende kategorieë te kon verdeel. Die ouderdomskategorieë wat gebruik is, is kinders (jonger as 18 jaar), jonk (tussen 18 and 25 jaar) en middeljarig (26 jaar en ouer). Statistiek met betrekking tot die invloed van oefening op depressie by die verskillende ouderdomskategorieë, word in tabel 2 weergegee.

Die meerderheid van effekgroottes is verkry van die jong ouderdomskategorie 18 tot 25 jaar (48,9%) en die middeljarige groep wat vir die doel van hierdie ontleding gestrek het van 26 jaar en ouer (46,7%).

Die eenrigting ANOVA vir die vergelyking van die gemiddelde effekgrootte van oefening op depressie tussen die verskillende ouderdomskategorieë, was nie betekenisvol nie ($F_{2,89} = 0,8505$; $p = 0,4307$).

Die z-waardes in tabel 2 toon dat 'n hoogs betekenisvolle verlaging van depressie deur oefening ($p < 0,001$) by al die ouderdomskategorieë gevind is. Daar was egter net vier effekgroottes by kinders (jonger as 18 jaar), wat dit moeilik maak om die verskillende groepe met mekaar te vergelyk. Daar is ook 'n negatiewe korrelasie tussen die verskillende ouderdomskategorieë en die effekgroottes vir depressie ($r = -0,1068$) gevind, maar dit was nie betekenisvol nie. Die feit dat depressie deur middel van oefening by alle ouderdomsgroepe verlaag word, word ondersteun deur die studie van McDonald en Hodgdon.[19]

TABEL 2
BESKRYWENDE STATISTIEK VAN DEPRESSIE TEN OPSIGTE VAN OUDERDOMSKATEGORIEË

Ouderdomsgroep	Aantal effekgroottes	$\bar{x}$	Sigma	z-waarde
Kinders	4	-0,6510	0,2587	-5,033*
Jonk	45	-0,4658	0,6412	-4,873*
Middeljarig	43	-0,7032	1,0632	-4,337*
TOTAAL	92	-0,5848	0,8582	-6,536*

* $p < 0,001$

Geslag

Geslag as veranderlike is in berekening gebring om te bepaal of daar 'n verskil is in die invloed van oefening op depressie by mans en dames. Sommige van die gekodeerde studies het in gebreke gebly om aan te toon wat die geslag van die proefpersone is en in daardie geval is die proefpersone gekodeer as manlik/vroulik. In tabel 3 word die resultate verstrek.

Alhoewel die vrouens ($z = -5,130$; $p < 0,001$) beter as die mans ($z = -1,986$; $p < 0,05$) gerespondeer het, toon die eenrigting ANOVA dat daar geen betekenisvolle verskil tussen die drie groepe is nie ($F_{2,91} = 0,3493$; $p = 0,7061$). Dit dien vermeld te word dat slegs 19 effekgroottes (20,2% van die totaal) vanuit manlike proefpersone verkry is, wat moontlik die vergelyking van resultate tussen die groepe kan beïnvloed. Die derde kategorie van manlik/vroulik dui ook op die antidepressiewe invloed wat oefening op beide geslagte het (z-waarde = -5,236; $p < 0,001$). Hierdie resultate word ondersteun deur verskeie navorsers.[20,19]

TABEL 3
BESKRYWENDE STATISTIEK VAN DEPRESSIE EN GESLAG

Geslag	Aantal effekgroottes	$\bar{x}$	Sigma	z-waarde
Manlik	19	-0,5999	1,3170	-1,986*
Vroulik	39	-0,5091	0,6197	-5,130**
Manlik/vroulik	36	-0,6742	0,7726	-5,236**
TOTAAL	94	-0,5907	0,8502	-6,736*

* $p < 0,05$
** $p < 0,001$

Gesondheidstoestand

Die gesondheidstoestand van die proefpersone is in twee kategorieë verdeel, naamlik oënskynlik gesonde persone (dit wil sê persone met geen genoteerde psigologiese of patologiese toestande of beide nie) en ongesonde persone (dit wil sê persone met genoteerde en gediagnoseerde klagtes, psigologies of patologies van aard). Hierdie resultate word in tabel 4 weergegee.

Beide die gesonde en ongesonde proefpersone se depressie het betekenisvol verlaag ($p < 0,001$). Die ongesonde groep se z-waarde (-4,977; $p < 0,001$) is die kleinste, maar geen beduidende verskil tussen die twee groepe is met behulp van die eenrigting ANOVA gevind nie ($F_{1,92} = 0,2731$; $p = 0,6025$).

Uit die bestudering van die gekondenseerde kategorieë van gesonde versus ongesonde proefpersone, blyk dit dat ook by gesonde persone depressie deur oefening verlaag kan word. Sommige studies en oorsigartikels uit die literatuur beweer dat oefening net 'n invloed het op persone wat reeds depressief is.[13,8,21] Hierdie meta-analise dui daarop dat depressie ook by oënskynlik gesonde persone betekenisvol deur oefening verlaag kan word. Hierdie afleiding word ondersteun deur Folkins en North.[22,20]

TABEL 4
BESKRYWENDE STATISTIEK VAN DEPRESSIE TEN OPSIGTE VAN OËNSKYNLIK GESONDE TEENOOR ONGESONDE PROEFPERSONE

Gesondheids toestand	Aantal effekgroottes	x	Sigma	z-waarde
Gesond	54	-0,5511	0,8783	-4,611*
Ongesond	40	-0,6442	0,8186	-4,977*
TOTAAL	94	-0,5907	0,8502	-6,736*

* $p < 0,001$

BESPREKING

Daar bestaan verskeie psigologiese teorieë en benaderings ten opsigte van gemoedsversteurings. Ten einde 'n verklaring te bied vir die antidepressiewe werking van oefening word die verskillende teorieë, wat die oorsake van depressie probeer verklaar, kortliks uiteengesit.

- Neurofisiologiese faktore wat predisponerend tot depressie optree, is 'n nuwe en interessante navorsingsveld waaruit die biogene-amiene-, hormoonwanbalans- en elektrolietehipoteses hulle ontstaan gehad het. Aanhangers van hierdie sienings is oortuig daarvan dat die basiese oorsaak van gemoedsversteurings in die sentrale senuweestelsel geleë is.[23,24,25] Alhoewel die presiese neurofisiologiese meganismes wat meebring dat oefening 'n verlagende invloed op depressie het, nog nie bo alle twyfel vasgestel is nie, het navorsers soos Taylor et al.[18] bevind dat oefening verantwoordelik is vir 'n verhoogde sinaptiese vrystelling van byvoorbeeld katesjolamiene in die liggaam. Katesjolamiene is 'n groep van oordragstowwe wat deur neurone in 'n sinaps vrygestel word en wat 'n rol in die geleiding van senuwee-impulse speel. Aansluitend hierby kan melding gemaak word van die studies van Ebert et al.[26] en Post et al.[27] wat bevind het dat die amiene-metabolietvlakke by individue verhoog na blootstelling aan verhoogde fisieke aktiwiteit. Die verhoogde simpatiese aktiwiteit wat voorkom tydens oefening, kan 'n verklaring bied vir die antidepressiewe werking van oefening.
- Die algemeenste oorsaak van depressie is waarskynlik geleë in stressors wat die lewe van individue van dag tot dag beïnvloed. Hier word gedink aan aspekte soos die dood van 'n naby familielid, huweliksprobleme, probleme by die werk, finansiële probleme, verhoogde verantwoordelikhede en eise wat aan 'n persoon gestel word, ensovoorts. Navorsing het nie alleen uitgewys dat depressiewe persone wel aan oormatige stres blootgestel is nie, maar ook die moontlikheid dat stressors op die lange duur veranderinge in die impulsgeleiding van een neuron na die volgende tot gevolg kan hê, wat dan weer 'n rol in die ontstaan van gemoedsversteurings speel.[28] Die opbouende rol wat oefening by individue met 'n hoë stresvlak kan speel, is deur verskeie navorsers aangedui. Hoe fikser 'n persoon is, hoe gouer kan die sisteme in die liggaam na normaal terugkeer na 'n stresvolle gebeurtenis.[29] Verhoogde aërobiese fiksheid het 'n buffereffek op die mate waartoe die liggaam op stresvolle situasies reageer.[30] Die negatiewe effek wat stresvolle lewens-ervarings op gesondheid het, verminder as die oefeningsvlakke verhoog word.[31] Die ontspannende invloed van oefening (weg van kwellende verantwoordelikhede), vermindering in liggaamsmassa, toename in fiksheid, buitelugrekreasie, sosiale interaksie en bemeesteringsukses het ook 'n positiewe effek.[32]
- Uit die psigodinamiese teorie blyk dit dat oefening wel 'n bydrae kan lewer tot die verbetering van die gemoedstemming van individue deur die fasilitering van insig by 'n persoon van homself, asook deur die ontwikkeling van self-dissipline en 'n begrip van persoonlike beperkings.[16,18,22]
- Volgens die gedragsteorie vind verbetering van die gemoedstemming van individue deur middel van oefening plaas en wel om die volgende redes:
  - Oefening het 'n inherente en verworwe versterkingswaarde vir die individu.
  - Oefening kan die vlak van gedragsafhanklike positiewe versterking by die individu verhoog.
  - Oefening kan die eiewaarde van 'n individu verbeter deur die individu se ervaring van fisieke verbetering en moontlike prestasie wat bereik kan word.
  - Die verbetering in die eiewaarde en fisieke voor-

koms van die individu gee weer aanleiding tot beter sosiale vaardigheid.[16,21,32]

- Die kognitiewe teorie verklaar die invloed van oefening op depressie soos volg:
  - Oefening kan 'n persoon se negatiewe gedagtes oor homself en die wêreld tydelik verbreek.

Die bewuswording van sukses deur die bemeestering van oefenaktiwiteite, kan lei tot selfaanvaarding.[31,18,32]

Uit voorafgaande is dit duidelik dat 'n verklaring vir die antidepressiewe werking van oefening nie voor die hand liggend is nie. Tot tyd en wyl die oorsake van die depressie nie duidelik is nie, kan die terapeutiese werking nie onomwonde verklaar word nie.

SAMEVATTING

Vanuit die meta-analitiese ondersoek dui die oorkoepelende resultate sterk op die positiewe invloed wat oefening op die verlaging van depressie het. Ten opsigte van die veranderlikes ouderdom, geslag en gesondheidstoestand is die volgende gevind:

- Die ouderdomskategorie kinders (jonger as 18 jaar) het die grootste verlaging in depressie getoon.
- Geen verskil in geslag is gevind nie.
- Ongesonde persone het beter resultate as oënkynlik gesonde persone gelewer.

Oefening as behandelingsmetode het dus beslis 'n positiewe invloed op die verlaging van depressie. 'n Multidissiplinêre spanbenadering van kundiges oor vakdissiplinêre grense heen word gevolglik bepleit ten einde 'n meer omvattende en effektiewe strategie van behandeling aan depressiewe pasiënte te kan voorsien.

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PRODUCT NEWS

Boots Healthcare South Africa – Commitment to Sports Medicine

As manufacturers and marketers of the well known anti-inflammatory agents, Brufen, Froben and TransAct $_{LAT}$Boots has over the years developed and maintained a high profile in Sports Medicine.

More recently Boots Healthcare South Africa (BHSA) reconfirmed their continued commitment to the science of Sports Medicine with the announcement of a R30,000 grant to the University of Cape Town Sports Medicine Department. The objective of this grant, which will be paid over 3 years, is to provide funding for a number of research projects related to Sports Medicine. These projects are integrated into the curriculum for the two year post graduate Sports Medicine course offered by the UCT Sports Medicine Department, as such there is also an indirect benefit to students which will enhance the study of Sports Medicine.

This grant also heralds Boots revitalised interest in Sports Medicine with the launch of TransAct$_{LAT}$, – the first ever NSAID in a patch formulation to be introduced in South Africa. The unique features of TransAct$_{LAT}$ render it ideal for the treatment of a wide range of musculoskeletal conditions associated with common sports injuries.

BHSA's involvement with Sports Medicine and particularly UCT Sports Medicine Department, however, dates back a few years and includes two other commitments.

The best Student Award for the UCT postgraduate Sports Medicine diploma was introduced some three/four years ago as an incentive for students. This award is in the form of a travel grant to the value of R5 000 to enable the winner to attend an international event of own choice.

In addition Boots Healthcare also sponsors the Annual Boots Gold Award in conjunction with the South African Sports Medicine Association. This award, a Kruger Rand, is for the best free paper presented at the annual SASMA Congress and was introduced 8 years ago. The objective being to provide recognition for outstanding effort in the field of Sports Medicine.

The 1995 Boots Gold Award went to Dr. C Jander of the UCT Student Health Department in Mowbray.

BHSA remains committed to Continued Medical Education and the development of Healthcare Services in South Africa to meet the challenges that lay ahead and to ensure the best possible standard of healthcare for all the people of South Africa. □

The fight against Athlete's Foot

Athlete's foot or (medically speaking) Mycoses of the feet is a phenomenon that occurs uniformly throughout the world, although it has been found that the incidence of Athletes foot may be higher in the industrialized countries. It is an easily treated common infection which affects mainly adult males and females. (However statistics show a slightly higher incidence in men.)

What is Athlete's foot

The definition describes it as a disease that is caused by fungi dermatophytes, yeasts and moulds which infect the areas between and under the toes and the soles of feet.

What Athlete's foot looks like

The most common form starts with reddening and scaling between the 4th and 5th toes. However, it may appear dry and scaly, moist, or in the form of blisters on the undersurface of the foot.

The wet form is characterized by the eruption of small pus filled blisters which often merge to form larger blisters. After 3-4 days they are either scratched open or burst. New blisters form on the periphery and are extremely inflamed.

The dry form appears in the form of isolated blisters below the skin surface. These blisters dry leaving small bare surfaces which can become painful crevices.

In all cases it is extremely itchy. If not treated promptly, the skin may tear and it could become infected with bacteria. This condition is difficult to treat and makes walking a painful exercise.

The Factors aiding Athlete's foot

Sweating is the contributing factor towards promoting this disease. The sweat provokes a break down of the horny layer allowing the fungi to penetrate into the deeper layers of the skin. Summer heat and the wearing of non absorbent nylon socks and stockings also aid in promoting fungal growth of the feet.

In some instances alkaline soaps alter the horny layer making it more permeable for the fungi. With active participation in sports it has been found that sportsmen and women are also very prone to fungal infections. Swimming in particular creates favourable conditions, as prolonged and repeated contact with water modifies the natural skin resistance allowing fungi to enter the layers of skin.

Those young men and women who are doing military service are highly susceptible to contracting this disease. The wearing of boots, sharing of dormitories and communal showers, and physical effort all assist in the contraction of this disease.

Treatment of Athlete's foot

Treatment of fungi of the feet generally depends on the fungal species whether they are local, occasionally generalised or mixed in nature.

Successful results have been found following short periods of treatment with Pevaryl. Pevaryl cream is simple to use as it is rubbed gently on the affected areas and between the toes – morning and evening. The cream contains Econazole nitrate which kills fungi. To combat remaining fungi which may be living in the shoes and which may cause re-infection, it is important to apply Pevaryl powder to the shoes prophylactically.

To either prevent or stop Athlete's foot it is advised that a person wears natural fibre socks, drys well between the toes and wears open shoes when possible. Avoid direct contact with wet floor areas in common ablution facilities by wearing thongs.

For and behalf of Roche Products (Pty) Ltd

For more information please contact Wayne Vanderwagen at (011) 442-3815 or 442-9561.