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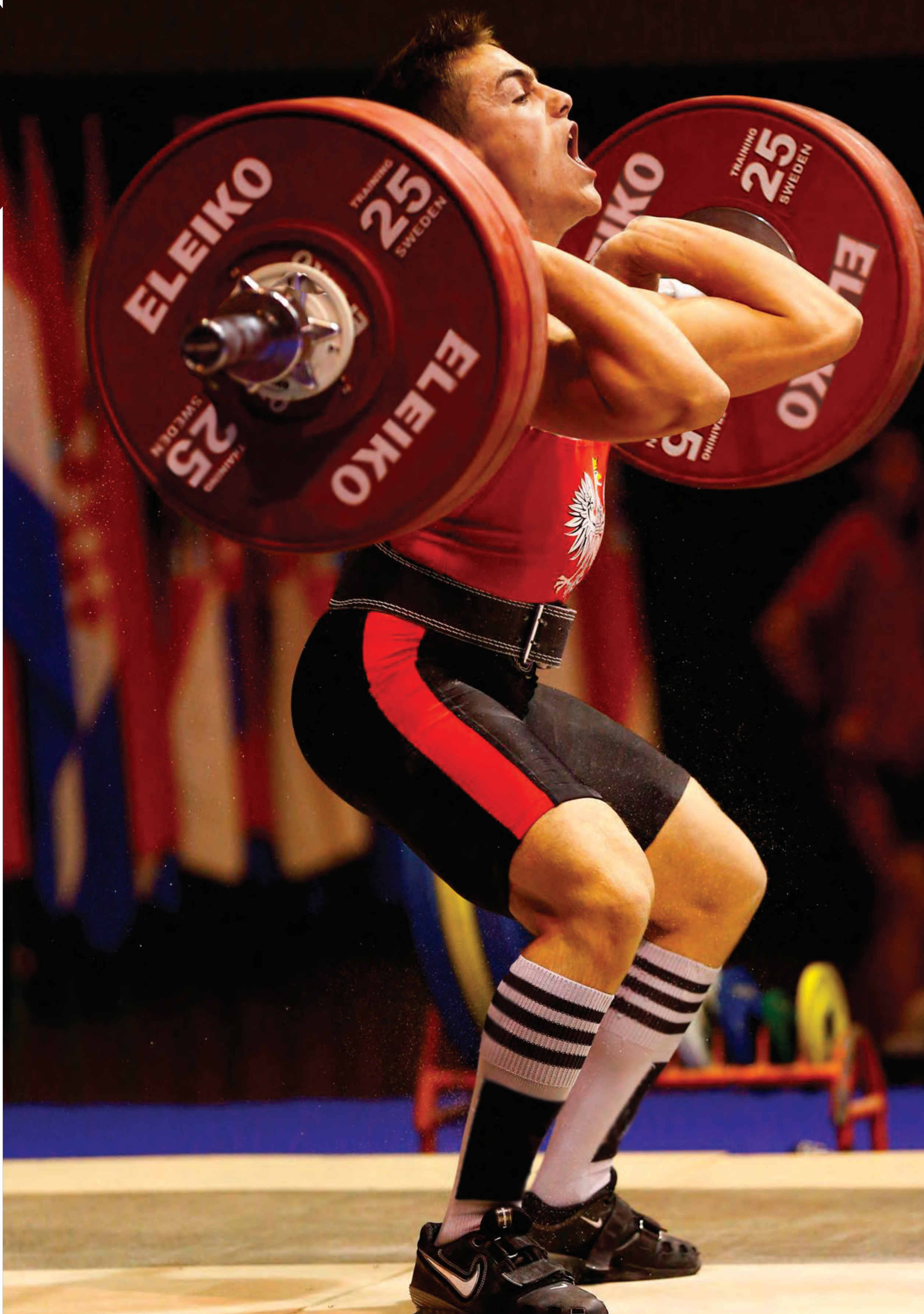

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EDITORIAL MISSION STATEMENT

The editorial mission of the EWF – Scientific Magazine is to advance the knowledge of human movement based on the assumption that it is firstly, by any standard, the expression of muscular strength and secondly, a way of life and an ethical approach entrusted to professionals who not only are highly qualified, but also have full knowledge of the scientific facts, as well as being specifically competent. From its first issue, EWF – Scientific Magazine, has set itself the ambitious goal of bridging the gaps between the scientific laboratory and the operator on the field, enhancing both the practical experience of the coaches and the results of applied research. Consequently, the editorial rule will be a constant reference to practice and the publication of recommendations on how to apply the results of research to the practice of movement and sport.

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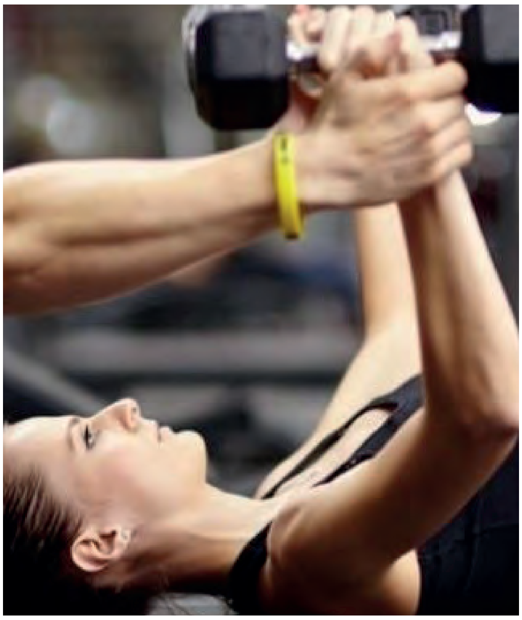
SUMMARY

..."Muscular tension in the working muscle groups during the performance of the explosion usually reaches optimum [with missed attempts at limit weights the force applied to the barbell usually exceeds the same force of successful attempts]".

Druzhinin, 1974



04

The concept of the "ideal athlete" became popular among soviet scholars and a number of research groups initiated and conducted studies directed toward the elaboration of appropriate models for elite athletes such as runners, throwers, swimmers, etc.

The benefits of physical activity (and the serious damage caused by neglecting physical exercise)

I'd say that by now we know enough, actually a lot, about this genre of human activity - motor activity, linked to movement - in particular, we know its beneficial effects and the very limited side effects (which can be expressed as "the less you do, the worse it is!"). Fortunately, not a day goes by that science, I repeat science, not just idle chatter, fails to show us more extraordinary marvels of the human body's adaptation processes and responses to this vital stimulus that is movement.

Italian research is regularly subject to criticism, yet it was here that a new hormone with extraordinary functional capabilities was discovered. It is called Irisin and takes its name from Iris, messenger of the gods and personification of the rainbow, a mythical Greek figure with wings to indicate the speed with which she executed the orders of Zeus and Hera. It's not a random name - this (new) hormone also has messenger functions.

The discovery, which could lead to an authentic revolution in the fight against osteoporosis, bears the signature of an all-Italian research group, as I pointed out, born from the collaboration between the University of Bari and the Marche Polytechnic University of Ancona, and supported by SIOMMMS (Italian Society of Osteoporosis, Mineral Metabolism and Skeletal Diseases), and is published in the official journal of the American National Academy of Sciences (PNAS).

The main feature of this hormone, already known for some years but for other attributes, is that it is produced only as a result of intense physical activity, and even in very low doses it has the ability to "manufacture" new bone: a recently discovered activity because, as previously mentioned, its initial physiological role discovered in 2015 was that of a "fat burner". Extraordinarily lipolytic activity was observed, so much so that the scientific world is considering its transformation into a drug for the treatment of obesity and, from today, it will also be employed in the fight against osteoporosis. Individuals suffering from advanced stages of both diseases are inhibited from carrying out a significant amount of physical activity.

For normal individuals, moving regularly and with a certain intensity is enough for the drug to be automatically produced by our muscles. Muscles are therefore no longer to be thought of as the sole performers of contractions and decontractions, but now even as endocrine organs. Although exercise is a well known and powerful stimulus

for new bone formation and the absence of gravity or loss of muscle mass causes bone loss, it was still unclear how muscles could communicate with bones. Today we have finally understood the mechanism related to how Irisin performs this extraordinary task of connectivity between muscle and bone, so much so that it is being considered a therapy for sarcopenia and osteoporosis, which occur in tandem in elderly bedridden patients or those unable to move, and as an endogenous resource (medication?) for those who, on the other hand, can physically exercise and sweat.
Irisin has been shown to have marked anabolic actions on the bone structure. This anabolic action is mediated mainly through the stimulation of bone synthesis, but with significant parallel reductions in the number of osteoclasts. Higher amounts of Irisin (3,500 g·kg^{-1} per week) cause browning of the adipose tissue; a fact that was not observed with low doses of Irisin. Presumably, low-doses of Irisin modulates skeletal genes, but not white adipose tissue. It was also noted that although the precursor of the Irisin, Fndc5 was abundantly expressed in skeletal muscle, other sites, such as bone and the brain, also expressed Fndc5, albeit at low levels. Furthermore, the muscle fibres of mice injected with Irisin showed a higher positivity of Fndc5 and the expression of Irisin-induced Fdnc5 mRNA in cultured myoblasts. The research data thus highlight a previously unknown action of Irisin, which could be the molecular entity responsible for muscle-bone connectivity.
Physical exercise has widely recognised benefits on metabolic and skeletal health and is routinely used as a non-pharmacological intervention in therapeutic protocols for a variety of diseases. Reducing the level of physical activity, for example in former athletes, can lead to a progressive loss of bone. Likewise, lack of activity and weightlessness invariably cause acute, rapid and severe bone loss, with a profound increase in the risk of fracture. For example, astronauts lose bone mass 10 times faster than women in early menopause, while patients in a vegetative state or with spinal cord injury present a high risk of fragility fractures, even at low bone mineral density (BMD).

Although there is a clear link between physical activity and bone acquisition and maintenance, the question of whether and how muscle function regulates bone mass has remained largely unresolved. Several lines of evidence point towards direct muscle-bone connectivity. First of all, increased muscle mass appears to be closely related to increased bone mineral density and, consequently, to a reduced risk of fracture in postmenopausal women. In contrast, age-related sarcopenia has been linked to senile osteoporosis. Secondly, excess glucocorticoids and vitamin D deficiency are catabolic, whereas androgens are anabolic for both bone and muscle. Thirdly, it has been observed how in rats with experimental spinal injury, electrical stimulation of the muscle saves the high bone resorption and osteoclastogenesis in vivo, basically providing direct evidence of muscle-bone communication, probably through a soluble molecule. The newly identified Irisin myokine, produced by skeletal muscle in response to exercise, has attracted attention as a potential target for the treatment of metabolic disorders.
The study previously showed that the myokine-enriched medium from myoblast cultures was capable of improving the differentiation of bone marrow stromal cells in mature bone osteoblasts in vitro. Here, we demonstrate that recombinant Irisin (r-Irisin), when injected into mice, increases cortical bone mass and strength. We find that this action results from a direct effect of Irisin on the formation of osteoblastic bone, which is mainly exerted through the suppression of sclerostin (Sost), a Wnt signal inhibitor. It was therefore believed that Irisin could act as the main molecule for the future development of new therapies that could simultaneously target bone, muscle and metabolic disorders.
So what is the purpose of this intervention? As if it were necessary, it is further proof that movement undeniably improves the quality of human life. Movement creates the conditions for structuring a more functional muscular bone system, both in terms of quality and quantity. Weight, as research highlights, favours these aspects in particular. So as of tomorrow, whoever you are, remember that 20 minutes of weight training can take you (but not just you, everyone the world over) with the goddess Iris to the Olympus of well-being. For your body and your mind.

Antonio Urso
EWF President

ATHLETIC TALENT: METHODO-LOGICAL FOUNDATION

BY VLADIMIR ISSURIN

Athletic Talent is a complex, multi-faceted phenomenon that is widely considered from methodological, biological, philosophical and social positions.

The available literature embraces a large body of findings and evidence that can be clustered into three basic branches: methodological foundation, hereditary and biological premises, data and evidence from sport psychology. The methodological foundation can be considered the basic background of general comprehension of the problem and fulfillment of various scientific and practical projects directed toward recognition, identification and promotion of talented individuals. Of course, the biological and psychological premises are major contributors of athletic talent and they will be considered later in the article.

1.1 BASIC POSITIONS AND CONCEPTS IN THE THEORY OF ATHLETIC TALENT

The problem of Athletic Talent is closely associated with the phenomenon and concept of athletic giftedness that can be characterized as a predisposition for and a higher learning rate/trainability for a given activity. In sports, properly developed giftedness implies attaining sports excellence and, therefore, achievement of Athletic Talent. The earlier this giftedness is identified, the more effectively the individual's athletic preparation can be managed and the greater is the probability of developing an elite athlete. Thus, a gifted child is potentially a talented athlete and, therefore, identification of gifted or potentially talented youngsters is very important and desirable. For further clarification, the following definition can be offered: Athletic Talent is a special extraordinary ability that allows an athlete to reach excellence in his/her sport activity.

The current literature introduces a number of popular concepts related to Talent Identification or Selection (TI and TS respectively) and Talent Development (TDV). Lidor with associates (2009) specify: "Talent selection involves the ongoing process of identifying athletes/players at various stages of the training program". The authors continued clarifying the long-term preparation process: "Talent development implies that the athletes/players are being provided with the appropriate learning/practice conditions to promote and realize their potential in a specific sport". Further investigation and practical interpretation of the TI and TDV problem has led to elaboration of a number of programs for earlier discovery of potentially talented athletes and their rational, efficient and scientifically based preparation (Hohman & Seidel, 2003; Ford et al., 2011; Anshel & Lidor, 2012 a.o.). The attempts focused on practical needs of high-performance sport will be reviewed below.

1.2 EARLIER STUDIES OF ATHLETIC TALENT

For many years, sport analysts and scholars have focused much of their attention on Athletic Talent. Traditionally, identification of athletic giftedness and talent for a given sport was associated with the optimal combination of anthropometric variables, high learnability and trainability, high motivation, persistence, and competitiveness (Ozolin, 1970; Harre, 1982). Despite the high importance and actuality of the problem of Athletic Talent, systematic studies of this phenomenon have a relatively short history. Further description of available materials highlights the concepts and evidence received from an earlier stage of investigations as well as those from the latest decades.

The studies devoted to the discovery of potentially talented young athletes primarily strived to find individuals who would be able to reach a level of outstanding mastery and earn the highest athletic rewards. These desires were firmly associated with social and political expectations, which were much more pronounced in former communist countries. This circumstance partly explains the appearance of prospective research programs in the early 1970's in East Germany and the USSR. These research projects were subordinated by appropriate authorities and oriented, first and foremost, to sports with a higher representation in the Olympic program.

1.2.1 EVIDENCE FROM EAST GERMANY

It should be noted that athletes from the former GDR (East Germany) attained very impressive achievements in international, high-performance sport, particularly in Olympic disciplines. From 1972 to 1988, GDR athletes earned 2nd place in the unofficial team medal rankings of Winter Olympic Games with one exception: in 1984 the GDR team earned 1st place.

A similar situation also occurred in the Summer Olympic program where the GDR athletes earned 2nd place twice in the unofficial team medal rankings (in 1976 and 1988) outperforming teams from the USA, Great Britain, Australia, etc. Although consideration of these magnificent successes was frequently associated with usage of non-legal pharmacological substances, contribution of scientific and methodological sources cannot be ruled out. The rational system of TI and TDV was definitely one of the most influential factors.

The studies of TI and TDV in the early 1970's were strictly oriented to earlier examination of young prospects, aiming their selection to regional centers of athlete preparation in various sports (Beamish & Ritchie, 2006). There were elaborate, complex evaluation programs that included anthropometric, physiological, psychological and sport-specific measures with appropriate norms and methods allowing for prediction of future achievements in given sports. The methodological demands for general evaluation of potentially talented youngsters influenced differential examination of the following components: (1) available level of athletic performance; (2) improvement rate of performances; (3) stability of progression of relevant athletic abilities (Harre,1971). These components required detailed characterization relating to techno-tactical, functional status, adaptability to training workloads, and psychological prerequisites.

The programs for complex evaluation of athletes contained general and event-specific tests that were executed in regional preparation centers using certified instruments and standardized protocols. Interestingly, several original tests broadened the borders of traditionally used approaches. Following anecdotal reports, the athletes of ball games were tested with regard to their intellectual abilities, aiming for the prediction of attainment of perfect tactical meaning and mastery. Such talent identification programs have been elaborated and implemented in artistic gymnastics, swimming, rowing, diving, figure skating, and several team sports.

To date, in accordance with the GDR rules of secrecy, descriptions and outcomes of these studies, where Athletic Talent was examined, have not been published in the available literature. From this position, a retrospective review of Kozel (1996) raises distinct interest. The author introduced a hierarchical system of TI and TDV in the GDR describing five layers:

1. The primary sport organizations such as school sport collectives, sport associations, and some sport clubs.
2. Sport schools with full time coaches who were responsible for talent scouting. These training centers were firmly directed toward high-performance preparation; their quantity approached 2000 and the number of hosted athletes was about 70,000.
3. Youth sport schools specialized exclusively in selecting athletic disciplines where all activities were determined by training demands. These 20 specialized training centers hosted about 9000 selected athletes.

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4. Sport centers of Army and Police had exclusive, independent status and had the privilege to recruit athletes from other training centers in the GDR.
5. The competitions of Spartakiades were organized periodically where medal winners received honored status like that of national team members.

Importantly, the preparation process of selected athletes was fulfilled following the training programs developed and controlled by the experts from National Sport Institute (DHfK Leipzig); the specific performance standards, norms and demands for competition and education were thoroughly prescribed. In these conditions, recognition of gifted and talented athletes was part of the whole preparation process. Interestingly, identification of talented youngsters was substantially based on their ability quickly acquire new technical skills following precise instruction. That means that GDR experts emphasized the role of learnability in TI and TDV. Besides this, the author of review emphasized the role and importance of highly qualified coaches who had been involved in evaluation of athletes at each stage of their long-term preparation. The last but not the least contributor of the successful TI and TDV system was efficient sport medicine assistance and valuable financial support of superior athletes.

1.2.2 EVIDENCE AND STUDY OUTCOMES FROM THE USSR

The studies of athletic giftedness and talent in the USSR were executed in accordance to a prospective centralized plan of research. One of the earliest methodological interventions into the area of TI and TDV was fulfilled by Zatsiorsky with associates (1973). The authors focused on the complex evaluation of Athletic Talent and proposed three modes of athlete selection:

1. primary sport orientation, aimed to determine suitableness of the individual for a given sport;
2. selection of appropriate candidates for a certain team or squad, taking into account their compatibility and correspondence to team-specific demands;
3. selection of athletes for participation in the highest level competitions.

The authors specified that the selection problem requires solving four research tasks: the formation of a model of the "ideal athlete;" prediction of decisive athletic abilities; classification the athletes following their results and sport history; and organization of entire evaluation and decision making process. The central link of the considered problem is the prediction of adult sport abilities (definitive variables) based on data from these athletes in earlier stages of their preparation (juvenile performances). Based on findings from long-term studies, the authors claimed that the most predictive values are those of improvement rate of relevant abilities during the initial 1.5 years of preparation. Special attention was given to hereditary factors where the authors reviewed four study approaches: investigation of sport dynasties, where family members have shown outstanding performances (1); determination of relationships between athletic abilities of parents and children (2); investigation of identical and non-identical twins (3); and dependence of several motor abilities on certain genetic markers (4). Concluding an extensive review, the authors stressed that selection of athletes to the National Olympic team should be fulfilled by taking into account their age, sport history and the remaining time span before forthcoming Olympic events.

The concept of the "ideal athlete" became popular among soviet scholars and a number of research groups initiated and conducted studies directed toward the elaboration of appropriate models for elite athletes such as runners, throwers, swimmers, etc. Correspondingly, several projects were fulfilled with the aim to find earlier predictors of definitive models for identification of gifted individuals having a predi-

sposition to a given sport and specific athletic disciplines. Such research has been realized using three different approaches: cross sectional studies, where most prospective candidates were chosen based on evaluation of body build and motor abilities in a large group of youngsters; retrospective analyses of athletic biographies of outstanding athletes; and longitudinal studies of young athletes during their long-term preparation. These three approaches can be illustrated by data of appropriate studies.

A large group of young soccer players, ages 9-10 years, was examined by qualified experts using anthropometric and physiological measures, general and sport-specific fitness tests, technical preparedness evaluations, as well as mental and willpower tests (Filin & Ismoilov, 1975). The authors found a relatively low impact of anthropometric and general fitness variables on sport-specific skills and technical status. They emphasized the usefulness of expert evaluation of technical preparedness, and especially for the mental/willpower component, which are decisive for future progression.

The second example relates to investigation of sport biographies of elite athletes. The long-term trend of athletic performances of 37 of the world's best sprint runners (average group result 10.06 s for 100-m) was analyzed from the age of 13 years until retirement (Tabachnik et al., 1977). It was found that all elite athletes had a very high level of initial results. The time duration to obtain a personal best result varied between 8.2 and 9.3 years depending on the age when the athletes started their purposeful preparation. The highest improvement rate was marked during the initial 4-5 years of preparation. The authors concluded that these revealed characteristics of the world best athletes can be utilized for elaboration of model characteristics of annual performance trends for long-term preparation of young sprint runners.

The third example refers to the findings from longitudinal monitoring of the preparation of 31 swimmers for 6 years – from age 11 to 16 years (Bulgakova & Vorontsov, 1978). The study design included periodical examination of anthropometric and physiological variables, maximum strength and flexibility, and swim-specific performances in the 50m, 100m, 200m, 400m, and 800m distances and an intermittent test of 4•50m. Stability of individual trends of various estimates was evaluated by means of correlations between juvenile and definitive performances. It was established that body size, ankle flexibility and swim performances in the 400m and 800m are the most predictive; these measures at age 11-12 give valuable information for prognosis of definitive status. Characteristics of strength and swim performances in the 50m, 100m and 200m were less predictive. The study's conclusion claimed that real prognosis of definitive status can be done at ages 13-14.

The monograph of Bril (1980) has summarized extensive data on the predisposition of young athletes to successful preparation and high athletic performance in team and dual sports. Analyzing the impact of various factors, the author distinguishes conservative prerequisites that cannot be compensated for during further preparation as the most predictive and decisive. These variables are body size and learnability. Furthermore, the author specified conservative prerequisites that can be compensated for during serious, purposeful preparation. This group of variables includes sensory motor responses such as space orientation, kinesthetic differentiation, audio-visual reactions, body balance and voluntary relaxation. One more group contains labile variables, which can be largely improved during long-term training such as motor fitness estimates, techno-tactical skills and sport-specific mental abilities. Several indicators having high stability trends during long-term preparation are considered to be the most predictive and valuable for prospective prognosis. They are running tests of 20m and 60m, a shuttle run, agility tests with and without dribbling, and jump performances. Similar to other analysts, the author specified different stages of athletes' selection:

1. initial selection aimed toward evaluation of the general predisposition of youngsters to a given sport; this stage duration is about 2 years;
2. prospective evaluation of potentially talented candidates; this stage duration is also about 2 years;
3. selection and formation of a concrete team;
4. selection to National team for high prestige tournament like the Olympic Games.

The author emphasized the importance of expert evaluation of sport-specific game activities in each stage of athlete selection.

A number of well-controlled, prospective studies were conducted by soviet and Bulgarian researchers in track and field during the period of 1970-80. An essential part of these findings was summarized in the collective monograph entitled "Selection and prognosis of predisposition to track and field" (Siris, Gaydarska, Rachev, 1983). The published materials embrace data from systematic studies in five disciplines of track and field: sprint running, long- and medium distance running, long jump, throwing, and decathlon. The five appropriate chapters contain characteristics of age, when world-leading athletes attained their best performances, characteristics of body build of elite athletes, modeled trends, and improvement rates of sport-specific fitness variables. The authors specified the probability of prognosis of definitive results to be about of 30-35% based on the initial evaluation of fitness components. Prognosis based on data obtained after 1.5 years of preparation reaches a probability of 75-80%. In conclusion, the authors postulated an organizational bases for selection procedures. They specified that the initial stage should include evaluation of children aged 9-11 years; the second stage includes evaluation of children at ages 11-12. Importantly, the variety of individual biological estimates and rates of maturity substantially complicate the objective evaluation of candidates; correspondingly, this factor should be thoroughly taken into account both on the 1st and 2nd stage of evaluation and selection. Although the studies of Siris with associates (1983) were conducted more than three decades ago, the published model characteristics of talented children may the raise interest of contemporary readers and will be considered in appropriate sections of this book (11.1.1 and 11.1.2).

1.2.3 EVIDENCE AND FINDINGS OF STUDIES CONDUCTED IN DIFFERENT COUNTRIES

A valuable methodological contribution to the problem of TI and TDV has been carried out by Bar-Or (1975), who proposed an original approach to identification of sport talented individuals. The author's proposed format was a five-step examination of potentially talented candidates, namely:

1. evaluation of morphological, physiological and psychological status of children and their performance estimates;
2. determination of maturity level;
3. evaluation of reaction to training following a relatively short-term program;
4. evaluation of athletic history of the family;
5. prediction of future performance using an appropriate multiple regression statistical model.

A serious review of Athletic Talent investigation was published by Gimbel (1976) who claimed that three decisive factors should be analyzed: morphological and physiological characteristics; trainability, and motivation. The author stressed the necessity to evaluate 8-9 year old candidates before their growth maturity spurt. He reasonably highlighted that achievement of top-level performances usually occurs at ages 18-20 when athletes have a training experience of about 8-10 years. According to the author's analysis, accuracy of earlier prognosis of Athletic Talent is very low and many youngsters evaluated as gifted and prospective do not reach a level of pure excellence. The author explained this failure of such prognoses by non-sufficient sensitivity and validity of tests (1), the inability to take into account biological age and maturity level (2), the impact of psychological factors, which were usually not assessed during earlier evaluations (3).

One of the most memorable publications devoted to Athletic Talent was

STAGES	RELEVANT CHARACTERISTICS OF ACTIVITIES		
	PERFORMER	MENTOR	PARENTS
INITIATION	ENJOYMENT PLAYFULNESS EXCITATION FAN ORIENTATION	CHEERFUL EDUCATION DEVELOPMENT OF AN ATHLETIC IDENTITY TALENT IDENTIFICATION	POSITIVE SUPPORT OF CHILD NOTICING CHILD'S GIFTEDNESS COOPERATION WITH MENTOR
DEVELOPMENT	COMMITMENT TO TRAINING POTENTIAL SELF-ESTIMATION MORE SERIOUS ATTITUDE TASK/ACHIEVEMENT ORIENTATION	SUPERIOR KNOWLEDGE STRONG PERSONAL INTEREST PROFESSIONAL GUIDANCE EXPECTATION OF QUALITY RESULTS	INCREASED MORAL AND FINANCIAL SUPPORT OTHER ACTIVITIES' RESTRICTION REASONABLE HEALTHCARE
PERFECTION	PRIORITY OF SPORT VALUES PSYCHOLOGICAL STABILITY PERSONAL RESPONSIBILITY FULL DEDICATION WILLINGNESS TO MEET HIGHEST STANDARDS	INTRODUCTION OF A MASTER COACH HIGH PROFESSIONAL LEVEL EMOTIONAL CONTACT WITH ATHLETE REASONABLE DEMANDING	REDUCED INFLUENCE

TABLE 1.1 - STAGES OF LONG-TERM PREPARATION OF TALENTED INDIVIDUALS ACCORDING TO MODEL OF BLOOM (1985)

conducted by Bloom (1985) and still remains a valuable contribution to the methodology of TI and TDV. Based on structured interviews of top-level swimmers, tennis players, and highly successful sculptors, concert pianists, neurosurgeons, and mathematicians, the author developed a model of talent detection and promotion. The model proposes a realization of three stages of long-term professional preparation (Table 1.1).

It is worth noting that unlike previous versions this model, Bloom highlights the importance and interaction between all participants of the TI and TDV process, i.e. the athlete, coach, and parents. The relevant characteristics of their activities over the each stage allows for a better understanding of this multifaceted process.

An original study of long-term preparation of elite athletes was conducted by Skanlan, Ravizza, and Stein (1989). The researchers interviewed 26 former top-level US figure skaters aiming to reveal their time expenses for training during different phases of preparation, chronological terms for these phases completion, sources of enjoyment that emerged from various circumstances, familial support, etc. The stages of preparation were specified according to Bloom (1985); their relevant characteristics are presented in Table 1.2.

The authors specified that the age when respondents started their athletic preparation varied between 4 and 14 (with an average of 8.7 yrs). Correspondingly, the duration of the initial phase was longer in younger athletes and shorter in adult novices. The preparation in figure skating was associated with substantial financial expenses and all respondents marked that they received sufficient familial support. The athletes noted that they received enjoyment associated with their activities and every-day life. Specifically, they marked enjoyment from the act of skating, from perceived competence, social recognition, and from life opportunities associated with their exclusive status.

It can be suggested that the general situation of talent promotion in US figure skating a few decades ago was rather typical for North American sport and very different as compared with TI and TDV in former Eastern European socialist countries. The gifted athletes were recruited to local sport clubs following their self-initiative and parental support. Their initial preparation was not supported by a local or centralized organization and financial resources and identification of their giftedness was the responsibility of local coaches and sport managers. Apparently, this situation has changed drastically during subsequent decades.

1.3 CONTEMPORARY PROJECTS OF ATHLETIC TALENT INVESTIGATION

Since the early 1990's the importance of Athletic Talent identification and nurturing has become widely recognized and the number of methodological publications all over the world has increased dramatically. Among the factors that were affected by this increased scientific and practical interest were great social and political changes in human society, which resulted in disintegration of the bloc of Eastern European communist countries and unification of Germany. These historical perturbations opened a new stage of liberalization of all forms of cooperation between the athletes, coaches, managers, and researchers. Many coaches and scientists from former communist states moved to Western countries with short-term projects and for long-term employment. Besides this, the sport organizations in Western countries become affected by political and social pressure associated with stronger demands to obtain leading positions in world sport (Bailei et al., 2010). At that time, the interest and attention to the problem of talent search was shared in various areas and in 1992, the International organization of Centers for Talented Youth was founded (Touron & Touron, 2011). Thus, since the early 90's, the number of research studies and analytical projects devoted to Athletic Talent increased dramatically.

PHASES	DURATION (YEARS)	DESCRIPTION
INITIATION	2-4	ONE GROUP LESSON PER WEEK IN FIGURE SKATING, ACQUISITION OF TECHNICAL SKILLS, INVOLVEMENT IN OTHER NON-SKATING ACTIVITIES
DEVELOPMENT	3-5	2-3 FIGURE SKATING SESSIONS PER WEEK, PRACTICING PRIVATE LESSONS, PARTICIPATION IN COMPETITIONS OF LOWER/INTERMEDIATE LEVEL; DECREASED AMOUNT OF NON-SKATING PHYSICAL ACTIVITIES
PERFECTION	4-12	HIGHLY DEDICATED PREPARATION ABOUT 4-7 HOURS/DAY, 5-7 DAYS/WEEK, 45-52 WEEKS/YEAR; PROFESSIONAL COMPETITIVE PRACTICE; MINIMAL LEVEL OF NON-SKATING PHYSICAL ACTIVITIES

TABLE 1.2. - CHARACTERISTICS OF LONG-TERM ATHLETIC PREPARATION OF 26 TOP-LEVEL US FIGURE SKATERS (BASED ON DATA OF SKANLAN ET AL., 1989)

1.3.1 FRAMEWORK OF PROSPECTIVE AND INNOVATIVE PROJECTS

During the latest decades, a number of extensive review-papers and reports of prospective projects have been published aiming to highlight contemporary approaches for solving the problem of TI and TDV in different countries. A summary of these recent publications is given in Table 1.3.

PURPOSE OF PROJECT/STUDY	DESCRIPTION	SOURCES, ORIGIN
Introduction of Australian system of TI and TDV of young prospects	The Australian system of TI consisted of 3 phases: school screening with anthropometric and fitness tests (selected students must be within the top 2%); determination of athletic preference (invited 10%); admission to appropriate sport organization	Hoare, 1996; Australia
Consideration and analysis of current development models	The project proposes four-stages model of TI and TDV that indicates chronological, methodological and physiological prerequisites of young prospects long-term preparation	Balyi, 1996; GB
Characterization of the familial support of talented athletes throughout their long-term development	Based on in-depth interviews, three phases of TDV were offered: the sampling, specialization and investment years. The phases' content, particularities and chronology are described.	Côté, 1999; Canada
Characterization of content, demands and particularities of long-term process of TI and TDV	There are three proposed phases of TI and TDV during multi-years athletic preparation that are focused on talent identification, development, and selection to an appropria-te group, team or squad	Williams and Reilly,2000; GB
Overview of traditional and modern approaches to development of Athletic Talent	Talent is described as dynamic manifestation of innate and environmental factors, where competent coaching, familial support, and meaningful practice play important role to attain superior performance	Durand-Bush, Salmela, 2001; Canada
Overview of scientific tasks and evidence related to TI and TDV	The proposed model of segmental stages of TDV embraces initial, juvenile, and final performances. It's claimed that innate factors dominate in mono-structured sports, but not in sports demanding information-processing abilities	Hohmann, Seidel, 2003; Germany
Characterization of current knowledge related to identification of gifted adolescents	Considers the Differential Model of Giftedness and Talent that emphasizes the role of learnability and precautions associated with maturity status and maintaining children at an early age	Vaeyens et al., 2008; Belgium and GB
Review of comparative studies associated with TI and TDV in various sports	Physical tests give reliable information for TI monitoring, but have restrictions in assessment of cognitive skills, an-ticipation and decision-making in sport games, and fatigue tolerance	Lidor et al., 2009; Israel, Canada and Germany
Critical review of available TI methods and offering of enhanced processing of TI and TDV	Psychological measures have great predictive value althou-gh they are not sufficiently used in TI programs. The TDV programs are a superior alternative to TI, providing efficient systematic athletic preparation	Anshel, Lidor, 2012; USA and Israel
Introduction of multi-disciplinary approach to TI and TDV realized in Swiss Institute of Sport	The 6-component TI program proposes evaluation of sport performance, improvement rate, motor abilities, psycho-logical and biological issues, and athlete's biography to support TDV of elite athletes	Fuchslocher et al., 2013; Swit-zerland
Developing of TI/TDV program and community services to schools and sports clubs	About 3% of youth athletes are selected to an appropriate club, team, etc.; about 0.5% enter national youth programs. They receive necessary facilities, qualified coaching, medi-cal care, and a program of competitions	Elferink-Gemser, 2013; Nether-lands
Characterization of TI and TDV National program realized in China	Hierarchical program contains: initial evaluation of the school level (1), training in regional youth sport schools (2), advanced preparation in boarding-schools (3), professional preparation in national centers (4), admission to national teams (5)	Burk, 2013; Germany

TABLE 1.3 - SUMMARY OF RECENT STUDIES AND PROSPECTIVE PROJECTS DEVOTED TO ELABORATION AND EVALUATION OF VARIOUS TI AND TDV SYSTEMS IN DIFFERENT COUNTRIES

STAGES, AGE, YEARS			
FUNDAMENTAL	TRAINING TO TRAIN	TRAINING TO COMPETE	TRAINING TO WIN
MALES – 6-10	MALES – 10-14	MALES – 14-18	MALES – 18+
FEMALES – 6-10	FEMALES – 10-14	FEMALES – 14-17	FEMALES – 17+

TABLE 1.4 - STAGES OF LONG-TERM ATHLETIC PREPARATION ACCORDING TO BALYI (1996)

The first publication listed in Table 1.3 introduces the Australian prospective project know as "Talent Search." The authors reasonably supposed that the amount of accurately measured information could be the crucial factor in TI with respect to a particular sport and successfulness of long-term preparation of youngsters. Such factors as physiques, physiological, psychological, and sociological were taken into account. About 2000 Australian high schools were involved in the evaluation process and 1% of the initially tested children joined the national TDV program. The application of this program resulted in substantial enhancement of Australian athletes in the junior World championships.

One of the serious review-papers devoted to long-term nurturing of young gifted athletes was published by Balyi (1996). Based on available findings of Eastern and Western sport-science literature the author presented an original model of long-term preparation that embraces four meaningful stages (Table 1.4).

According to Balyi's model, the 1st stage is devoted to the development of general physical abilities and basic movement skills such as running, jumping, throwing, agility, speed and balance. Strength exercises can be used with body weight and medicine balls. The author emphasized that "FUN" is an important component of this stage. The 2nd stage is directed toward the acquisition of physical and mental skills for a specific sport. The athletes should acquire basic technical/tactical skills, basic techniques such as warming up, cooling down, stretching, etc. The competitive practice becomes part of preparation, although its contribution remains relatively small. The 3rd stage includes a sport-specific, highly individualized program with a high contribution from competition and the utilization of high-intensity exercises. The training components such as fitness, tactics, recovery programs, and psychological preparation are firmly directed to competitive demands. The 4th stage is the final in the framework of long-term preparation; it is directed to attainment of the highest athletic rewards and includes the most efficient and advanced means and methods of training and recovery. Its duration depends on the successfulness of athlete and the level of his/her physical and mental abilities.

The above-presented model of Balyi provides reasonable content and sequencing of preparation stages although it largely contradicts the reality of several Olympic sports and experiences of a numerous outstanding athletes. Such sports as figure skating, artistic and rhythmic gymnastics and swimming give many examples of magnificent performances of 15-16 year old athletes. On the other hand, the duration of FUNdamental preparation (4 years) seems unreasonably excessive for talented youngsters. Nevertheless, as a general scheme, it has distinct value.

The paper published by Côté (1999) introduced the outcomes of an in-depth study of families of elite rowers and elite tennis players with a focus on appropriate "stages of sport participation." The first stage was named "Sampling Years," where age varied between 6 and 13. It was characterized by the involvement in diversified, pleasurable activities that can be qualified as an intentional or deliberate type of play. Thus, the term "deliberate play" is actively used by analysts and experts in TI and TDV. The author found that during this stage, the parents recognized the giftedness of their children and gave financial support for their activities. The second stage labeled "Specialized Years" corresponds to ages 13-15 and is characterized by increased sport-specific activity and decreased contribution of extra-curricular activities, focusing on the development and perfection of specialized skills. The author noted that fun and excitement still play important role in earlier experiences of studied elite athletes. However, the study revealed that at this stage the parents develop an increasing interest in preparation and achievements of their gifted children. The next stage termed "Investment Years" started at age 15 and was characterized by much more pronounced training and competitive activities. Any kind of play activity was replaced with a tremendous amount of athletic practice. The role of parents at this stage changes as well. Although they are not immediately involved in the training process, they have shown increased activities to facilitate athletic preparation of children. In addition, they actively participate in the consideration of future plans, giving advice regarding continuation of the athletic career.

The study of Williams and Reilly (2000) was devoted to TI in soccer. Nevertheless, they produced valuable, methodological input for talent evaluation and nurturing in any sport. They stated that Athletic Talent is characterized by an optimal combination of anthropological, physiological, psychological, and social prerequisites. These authors described a general framework that introduces the three most important processes related to Athletic Talent, namely: talent identification, talent development, and talent selection (Table 1.5).

PROCESS	DEFINITION	COMMENTS
Talent identification	Recognition of athletic candidates' potential to attain exceptional performance and excellence in given sport	This process presupposes evaluation of relevant estimates and monitoring training over the timespan
Talent development	Provision of optimal conditions for realization of available potential and attainment of exceptional performance	This embraces subsequent stages of the long-term athletic preparation
Talent selection	Inclusion of talented individuals into appropriate preparation structures, teams and squads	This includes a number of selection procedures with gradually increasing demands

TABLE 1.5 - CHARACTERIZATION OF ATHLETIC TALENT IDENTIFICATION, DEVELOPMENT AND SELECTION (BASED ON WILLIAMS AND REILLY,2000)

The extensive review of Durand-Bush and Salmela (2001) summarizes findings of traditional and updated approaches related to TDV in sport. The authors reasonably claimed that although hereditary prerequisites have a strong impact and cannot be changed, the possible manipulations with environmental factors including competent coaching can largely determine the quality of athletes' preparation and achievement of exceptional performance.

The German researchers Hohmann and Seidel (2003) examined scientific aspects of TI and TDV focusing on available knowledge and prospective approaches to further efforts. They emphasized that early TI is extremely desirable for advanced preparation of young athletes and an important condition for their successful realization of athletic potential. Moreover, early TI is particularly important in cases of early specialization, which is very typical in contemporary sport. The authors reasonably outlined four integrative criteria for early diagnostics of Athletic Talent, namely: juvenile performance, where prediction accuracy varies between 20 and 65% and more reliable prognosis can be usually done after puberty (1); improvement rate of performances that should be analyzed taking into account the natural enhancement trend associated with the phases of long-term preparation and the maturation process (2); utilization of performance-specific conditions such as movement technique, coordinative and appropriate morphological prerequisites (3); and load tolerance, meaning favorable adaptation and low incidence of injuries (4).

The serious restrictions of traditional approaches and more advanced framework for understanding TDV perspectives were considered in publication of Vaeyens with associates (2008). Deficiencies of current approaches to TI were considered focusing on the widely used method of cross-sectional studies. They highlighted that cross-sectional studies are based on the assumption that extra-ordinary abilities of elite athletes can be extrapolated to earlier stages of preparation; in fact, as the authors claimed, many athletic qualities may not be apparent until

late adolescence. The maturation process seriously confounds the possibility of TI at earlier stages of preparation; as a result, the later developers may be underestimated as compared with their early-matured peers. In addition, the authors outlined the necessity of multidimensional evaluation of youngsters, contrary to the popular one-dimensional approach. The valuable theoretical input of this review is associated with the application of the Differential Model of Giftedness and Talent as the framework for TI and TDV interpretation. The model proposes that natural abilities embrace four broad domains: intellectual, creative, socio-affective, and sensorimotor. Of course, the physical component is dominant in athletes. However, the multidimensional nature forms the basis for both sport talent and sport gift. Giftedness is considered the possession of a high level of natural abilities; among the top 10% of same age peers.

Valuable methodological input has been provided by Lidor, Côté and Hackfort (2009) who introduced principal positions related to multi-component testing for TI and TDV. Based on an extensive review of relevant publications, the authors emphasized the main benefits and typical restrictions of current approaches to talent detection and promotion. Comparing the Eastern and Western approaches to TI and TDV the authors claimed that in first case, the major efforts were directed to recognition of the most talented prospects, whereas the Western practice was mostly oriented to talent development. In both cases the tests' batteries included evaluation of physical, physiological, motor and skill components. Considering the benefits of complex evaluation, the authors noted that physical skills tests combined with anthropometric measures have a distinct value in the prediction of future successes both in individual and team sports. However, such factors as cross-sectional study design and insufficient attention to the maturation process substantially reduces the persuasiveness of studies' outcomes. Typical limitations of TI and TDV of young prospects were pointed out:

1. The personality traits that are very important for prognosis are usually not tested and not included in evaluation models. Such indicators as willpower and ability to cope with competitive stress are extremely important but are not taken into account.
2. The cognitive skills i.e. anticipation, decision making, game understanding, etc. are extremely important for team sports, but are usually not evaluated during available TDV programs.
3. The team sports testing batteries should contain not only individual tasks but also modeling of "real-world" situations with gradual evaluation of task results.
4. Physical skills tests performed in a rested state do not provide sufficient information for prediction. Fatigue tolerance should be taken into account as well.

The perspectives and applicability of talent detection programs were thoroughly considered in a review from Anshel and Lidor (2012). A number of prospective TI programs for various sports, which included testing of motor abilities, physical skills and anthropometric measurements were reviewed. Their implementation resulted in an increased number of gifted youngsters involved in serious preparation, enhanced quality of domestic competitions, and even an increased number of international-level athletes. A special aspect of TI programs is their valuable assistance in the choice of an appropriate sport in the early stage of athletic preparation. The deficiency of these programs is the lack of psychological measures that substantially contribute to the accuracy of future success prediction. The paper includes an extensive summary of psychological characteristics indicated by different researchers for distinguishing between more and less successful athletes. Importantly, the most widely indicated characteristics that discriminated skill level were self-motivation and self-confidence. Nevertheless, the authors noticed that the accuracy of talent prediction is markedly decreased due to the limitations of research methods, self-reports, and anecdotal reports. The deficiency of these programs is the lack of psychological measures that substantially contribute to the accuracy of future success prediction.

The valuable experience of the Swiss Federal Institute of Sport Magglingen has been described in the publication of Fuchslocher et al. (2013). Unlike the theory of deliberate practice, the authors developed a "deliberate programming" approach that has been realized in follow-up practice with the Swiss elite and sub-elite athletes. The authors introduced the assessment criteria for evaluation and success prediction of young athletes. The scale of prognosis validity presupposes gradual evaluation of various criteria in terms of their predictability for achievement of superior performance. The highest rank was given to five estimates: performance at late junior age, testing of sport-specific performance, outcomes of competitive performance, achievement motivation, and resilience. Average but still significant impact was given to environmental factors and body build. The other estimates were qualified as less affecting on elite sport success. Nevertheless, such basic integrative characteristics as biological development and maturation level are thoroughly examined and taken into account during the final consideration of athletic status of candidates.

The current situation with TI and TDV in the Netherlands was analyzed and commented on in the publication of Elferink-Gemser (2013). The framework of the National Olympic Committee embraces 90 national sports federations, which fulfill regular athletes' preparation within more than 27,000 sports clubs. The district and national youth selection teams are formed as a result of TI by the sports clubs. Long-term experience shows that about 3% of youngsters are qualified as potentially talented; they join district selection teams for further systematic preparation. Ultimately, less than 0.5% teenagers are invited to national youth selection groups. Of course, this final selection is performed based on improvement rate, learnability, attitude to training, while at the same time taking into account the ideal profile of a talented athlete specific to the sport. The research group for Talent Identification and Development in Sports from the national HAN University of Applied Sciences is focused on further investigation of three principal research themes such as 'smart choice of sports,' 'talent identification,' and 'talent development.'

The recent publication of Burk (2014) contains valuable information concerned TI and TDV in China. A hierarchical system of multi-stage evaluation of young prospects has been adopted following purposeful regulation of the central State Sport Authority and has a long-term history of successful implementation. The 1st stage is directed toward initial evaluation and reasonable choice of the most suitable sport for the examined athletes. This stage is executed on the school level by physical education teachers and coaches. The 2nd stage presupposes regular preparation of selected candidates in regional youth sport schools. The 3rd stage embraces advanced preparation of the most prospective candidates within the boarding-school system, where the athletes train 4-5 hours a day 5-6 days a week. The 4th stage includes professional preparation in national athletic centers, where the volume of training routines subsequently increases. The top-level of hierarchy is preparation within the system of national teams, where daily time expenses for training reaches the level of 10 hours. The author noticed that after the 2008 Beijing Olympic Games, new tendencies in top-level athletes' preparation have occurred. There are some trends in decentralization, liberalization, and commercialization.

Concluding this section it is worth noting that reviewed papers largely contributed to the methodological foundation of Athletic Talent detection and promotion. To note, serious research projects have been realized in countries with deep athletic traditions and successful representation in the International Olympic program. On one hand, the high Olympic ambitions and expectations presuppose elaboration of serious multifaceted programs for searching and promotion of young talents. On the other hand, realization of such projects leads to an increased number of highly qualified athletes and ultimately to achievement of exceptional athletic performances.

1.3.2 EVIDENCE FROM STUDIES THAT EVALUATED GIFTEDNESS IN YOUNG ATHLETES

The purpose of this section is to display and consider examples of practically oriented studies where young athletic prospects were evaluated and the most gifted individuals were identified. For a long time, the attention of researchers and coaches was on determining the relevant predictors of Athletic Talent. Such reasonable predictions can be made based on the most favorable combinations of anthropometric, physiological, and fitness estimates for different ages. Such age related models can be created through longitudinal study of a large group of athletes, where one sub-group attains the elite level. Data for the athletes recorded in the different periods can be used as model characteristics for corresponding age categories. It is obvious that such a study, which would take a number of years, appears difficult and has organizational problems, but such long-term research projects have been conducted (see Table 1.5). Much more common are so-called cross-sectional studies that compare less successful and more successful youngsters. The results are used to reveal some specifics about hypothetically gifted athletes. Let's consider a number of studies that represent the findings of cross-sectional and longitudinal investigations (Table 1.6).

SAMPLE	STUDY'S DESCRIPTION	STUDY'S OUTCOMES	SOURCE
The USA tennis National team members (age 15.4 yrs), sub-elite players (age 13.6 yrs) and 250 young players	CSS*. Test battery included speed, agility, strength, flexibility and injury risk data. Testing was fulfilled during special training camp	The tests results yielded an accurateness of prediction for proper group of competence: 85.7% for National team, 91.3% for sub-elite and 95.5% for the rest of the players	Roetert et al., 1996
173 candidates for rugby club without previous training. Age of athletes - 10 yrs	CSS*. 14 motor tests (speed, agility, strength, flexibility) and 14 anthropometric data were measured	Using evaluation profile from 45 top-level players all candidates were classified in according to their predisposition with accurateness 93.8%	Pienaar et al., 1998
16 elite and 15 sub-elite soccer players aged 16.4 yrs	CSS*. Test program included soccer-specific skills, fitness, anthropo-metric, physiological and psychological data	The most discriminating variables were speed, agility, anticipation skill, aerobic power, fatigue tolerance, and ego orientation	Reilly et al., 2000
24 elite water-polo players aged 14-15 yrs	LS*. Test battery included 6 swim trials, dribbling, shooting, "jump" from water, and game intelligence. Follow up during 2 yrs	The selected roster had initial superiority in swim tasks, dribbling and game intelligence. Prediction for 67% of players was in agreement with final selection	Falk et al., 2004
405 novices handball players aged 12-13 yrs	LS*. Test battery included height, weight, speed, explosive power and a slalom dribbling. 2 yrs follow up program	Comparisons between selected to National team and other players have shown that only slalom dribbling served as good predictor of giftedness	Lidor et al., 2005a
10 judo athletes aged 12-15 yrs	LS*. The general abilities tests and judo specific set (10 skill tasks stations) were conducted 3 times during 2 years	The athletes' ranking 8 yrs after the testing did not meet agreement with the results of judo specific test, which is not sensitive enough to predict talent of athletes	Lidor et al., 2005b
15 adolescent elite volleyball players aged 16 yrs divided to starters (S) and non-starters (NS)	LS*. The battery inclu-ded speed, agility, explosive power, endurance tests and 2 skill tasks. 15-months follow up program	Only one test – vertical jump with approach- revealed difference between S and NS groups. The other tests did not reveal impact of athletic competence	Lidor et al., 2007

ABBREVIATIONS: CSS –CROSS-SECTIONAL STUDY; LS – LONGITUDINAL STUDY
TABLE 1.6 SUMMARY OF STUDIES WHERE GIFTEDNESS AND ATHLETIC TALENT WERE EVALUATED

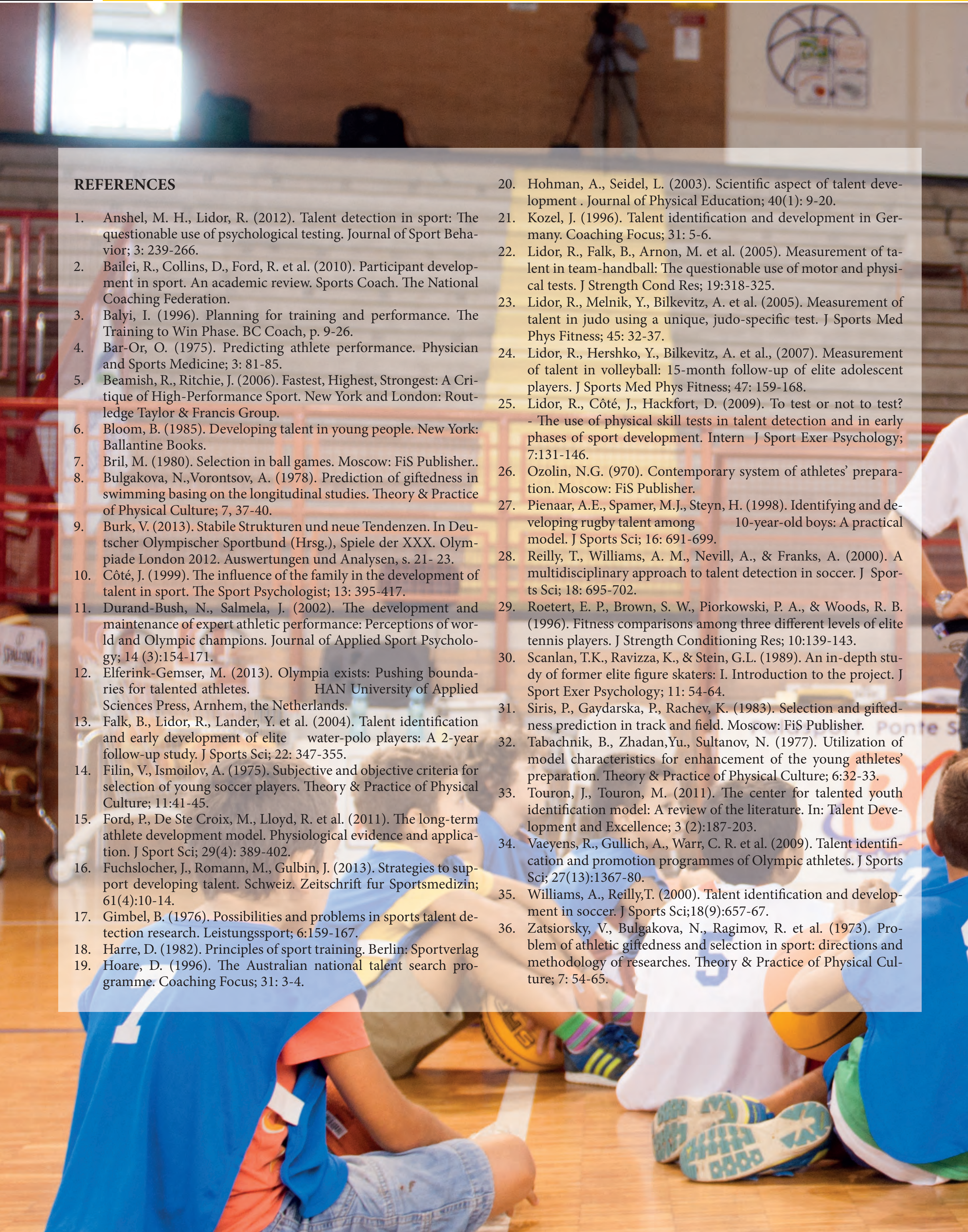
The overview of the above presented research findings shows a variety of study outcomes that display different tendencies in Athletic Talent prediction and identification. Employment of a complex test battery in novices and low-level athletes allowed for recognition of more prospective candidates in rugby (Pienaar et al., 1998) and in handball (Lidor et al., 2005a). These data definitely have practical value for further athletic preparation of prospective candidates. Importantly, the inclusion of sport-specific motor tests has particular value due to their higher sensitivity to targeted abilities. The apparent perspective is also to evaluate athletes in groups of different competence, which allows one to find the most discriminating indicators that can be used for potential talent identification. Such studies were successfully conducted in tennis (Roetert et al., 1996), soccer (Reilly et al., 2000), and volleyball (Lidor et al., 2007). Particular interest is raised from the data of the longitudinal study where test results at early phases of athletic development were matched with successfulness of athletes after long-term purposeful preparation. The research project with young judo prospects led to unexpected results; the fitness monitoring during two years did not reveal predictive potential in either general or sport-specific variables as compared with athletic ranking of these trainees eight years after completion of a follow up program (Lidor et al., 2005b). The reasons of such "prediction failure" could be associated with low homogeneity of the group (initial age varied between 12 and 15) and relatively low sensitivity of the test battery to highly specific judo athletic abilities. In any case, each single study listed in Table 2.5 gives certain information that can assist the coach in more reasonably selecting tests and indicators of giftedness and more consciously evaluating sport-specific potential of athletes.

SUMMARY

Athletic Talent is definitely one of the most intriguing and widely discussed issues in sport science and practice. Although there has been interest in this problem since many decades ago, when high-performance sport became a reality of social, cultural, and political life, the systematic studies of Athletic Talent have a relatively short history. In fact, the serious investigations of Athletic Talent were only been initiated in the early 1970's in Eastern European countries. One of the most efficient, hierarchical systems for talent identification and development was elaborated on and fulfilled in East Germany (former GDR). The serious, methodological input to theoretical and evaluation background of TI and TDV was done in the USSR. A number of prospective studies were also conducted in Western European countries and in the USA. Since the early 1990's, experience from former communist countries became available for the community of international training experts and analysts. As a result, a number of "talent search" projects were successfully realized in Australia, Canada, Great Britain, the USA, the Netherlands, Belgium, Germany, and Switzerland. The tremendous progression of Chinese Olympic athletes was, to a great extent, conditioned by the application of a strictly structured system of talent search and nurturing from the school level until national Olympic centers and national teams.

During the latest decades, a large number of studies have been conducted to verify batteries of relevant estimates for evaluation of giftedness of athletes in different sports. Employment of various tests such as motor fitness, physical skills, body build, physiological, and psychological abilities in different combinations allowed recognition of more prospective candidates with an accuracy that varies between 67-95%. However, this accuracy drastically decreases in attempts to predict talent from a long-term perspective.

Summarizing the evidence from prospective, long-lasting projects and practically oriented studies conducted for the needs of certain sports, a number of relevant issues can be highlighted, namely:
- the commonly accepted approach presupposes the division of long-term preparation into a number of stages where various age and sport-specific tasks be solved and young athletes overcome appropriate phases of their giftedness and talent evaluation;
- the objective difficulties in TI are associated with differences in the rate of maturation and unevenness of biological and sport-specific development of young prospects;
- serious restrictions of early evaluation of giftedness and talent are associated with the lack of psychological measures and insufficient attention to personality traits that, to a great extent, determine the achievement of exceptional performance;
- the TI in team sports needs more sensitive tests for prediction of successful game activity; such an item as fatigue tolerance was not taken into account by training experts and analysts.



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THE BIO-MECHANICS OF THE SARCOMERE, THE ORIGIN OF MUSCULAR FORCE

PART TWO

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THE ANATOMY OF THE SARCOMERE

The typical striation that occurs transversely to the contraction axis of voluntary somatic skeletal muscles is due to the structural details of the individual sarcomeres[1]. Observed under an optical microscope, the striation has a lighter area, Band I, and a darker area, Band A. The two bands differ from the spatial organisation of the molecules - isotropic, uniform and invariable in Band I (I is the initial of the term "isotropic"), yet anisotropic, discontinuous and variable in Band A (the A is the initial of the term "anisotropic"). At the centre of both bands we see two thin dark lines, that of Band I is the Z Disc and represents the terminal part of the sarcomere (the Z derives from the German term zwischenscheibe, which means "between" two adjacent sarcomeres), that of Band A is the M line and represents the support structure at the centre of the sarcomere (the letter M derives from the German term mittelscheibe, which means "in the middle" of the sarcomere). The clear areas that are observed in Bands I, around the Z Discs of the sarcomeres at rest, are characterised by the presence of actin filaments. The area around the M line, in the centre of Band A, with a clearer aspect than the body of the entire sarcomere, is called Zone H (the letter H derives from the German term hellerscheibe, which means "pale area" in the centre of the sarcomere) and is characterised by the presence of myosin protein strands. A sarcomere is then delimited longitudinally by two successive Z discs (Figure 1), respecting the concentricity of the sequence of the areas with different colour contrast: Z Disc - Band I - Band A - Zone H - M Line - Zone H - Band A - Band I - Z Disc. During the contraction, actin and myosin overlap in Band A and their mutual sliding produces a narrowing of the lighter areas of the sarcomere[2].

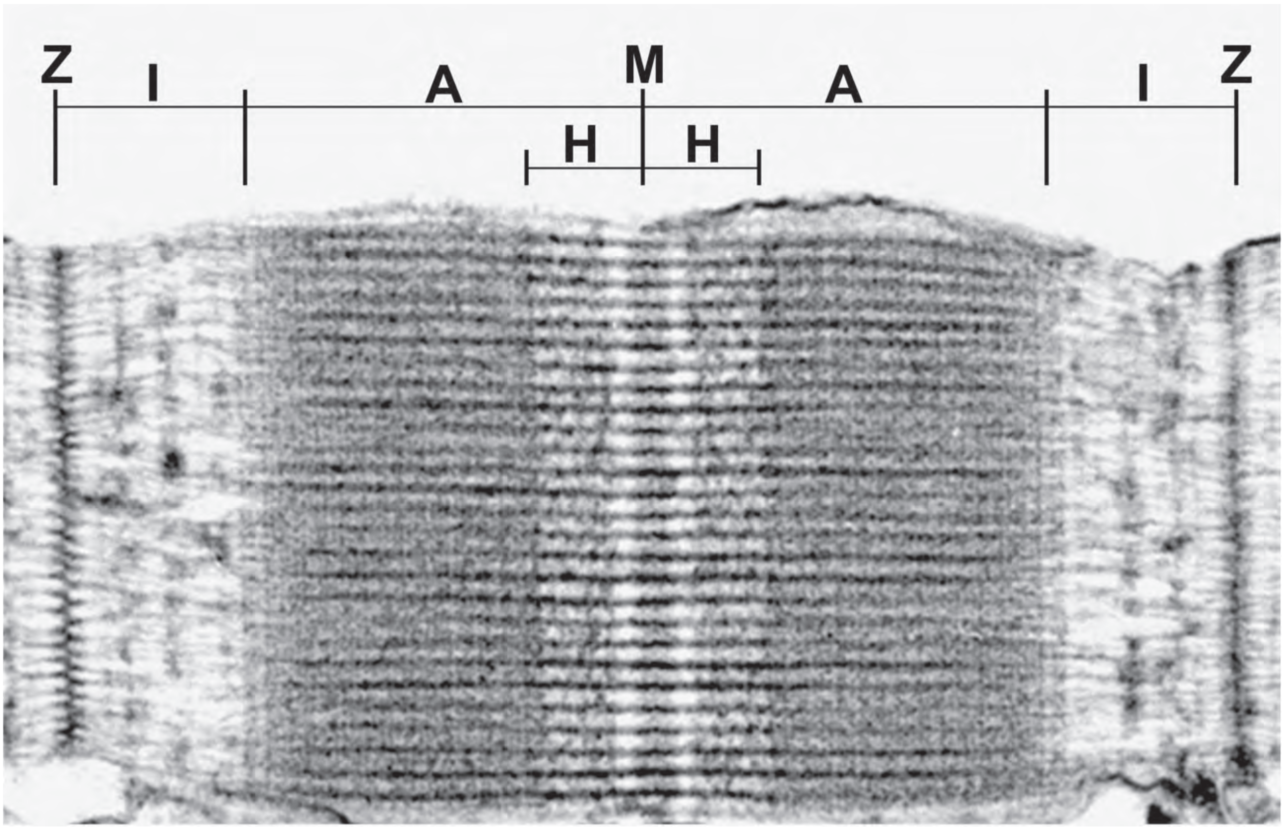

Figure No. 1

Electronic scan of the longitudinal section of a microscopic-scale sarcomere. The figure is composed of two clear areas, the I Bands, and two dark areas, the A Bands. The clear areas are bordered externally by a more marked trait, the Z Disc, which marks the end of the sarcomere. In the middle of the dark areas there are two lighter areas, the H zones, which join a darker section at the centre of the sarcomere, the M line, towards which the whole cellular structure compresses during contraction.

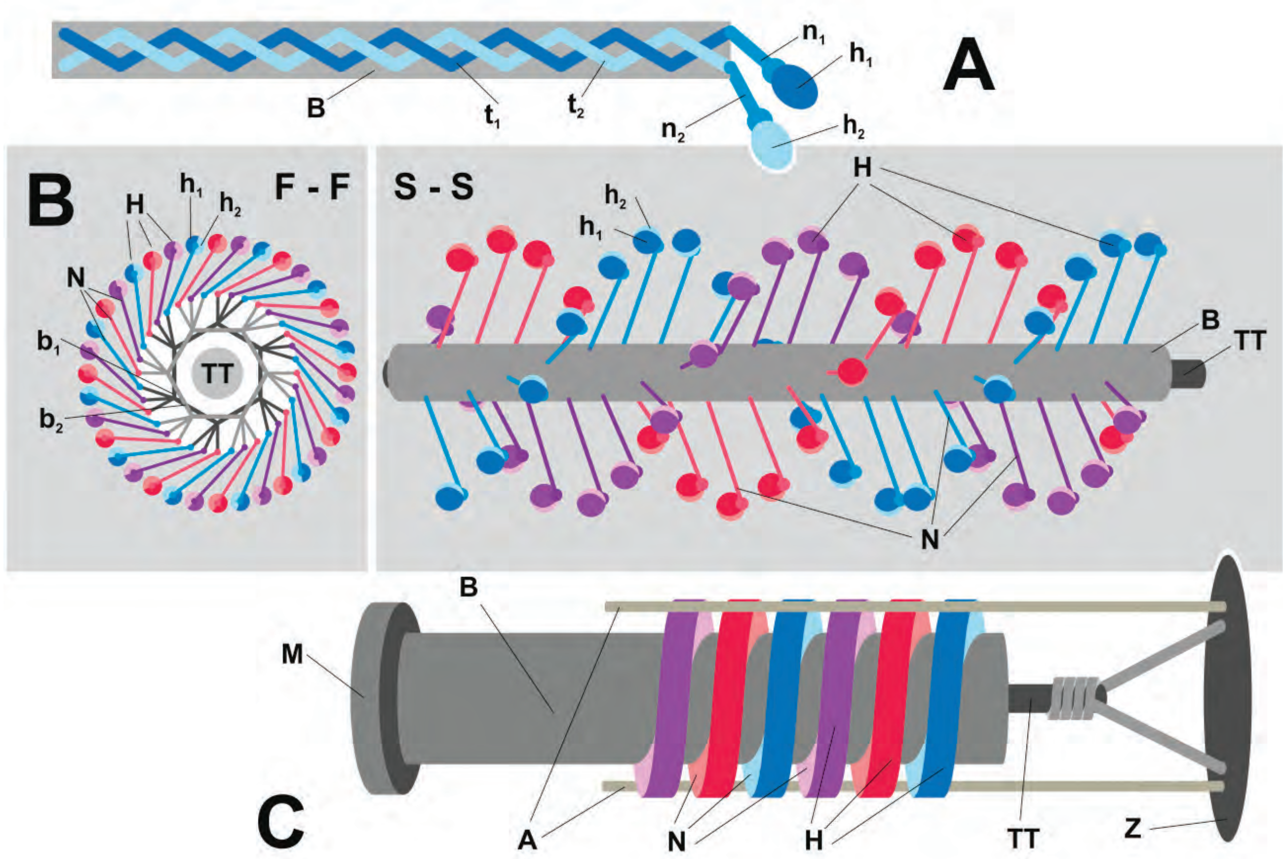

FIGURE NO. 2

BIOMECHANICAL DIAGRAM OF A MYOSIN AXOSTYLE. A) A THIN FILAMENT OF MYOSIN (B) IS MADE UP OF TWO FILAMENTOUS PROTEINS, WHOSE TAILS (T1 AND T2) FORM AN INTERLACEMENT THAT OPENS NEAR THE TWO ELASTIC NECKS (N1, N2) ENDING WITH TWO HEADS (H1, H2) THAT ARE FREE TO MOVE IN THE SARCOPLASM. B) A THICK FILAMENT OF MYOSIN ORIGINATES WITH THE FUSION OF 18 THIN STRANDS OF MYOSIN. SEEN TRANSVERSELY (F-F), THE THICK MYOSIN FILAMENT HAS A DOUBLE HEXAGONAL BASE (B1 AND B2) THAT DEVELOPS ALONG A TITIN FILAMENT (TT). THE 18 PAIRS OF NECKS (N) EXTEND FROM THE CENTRAL BODY OF THE FILAMENT OFTEN TO MAKE A CROWN OF 18 GROUPS OF HEADS (H), EACH OF WHICH IS FORMED BY TWO PROTEIN TERMINALS (H1 AND H2) PLACED IN THE DIRECTION OF THE CLOSEST ACTIN MOLECULES. SEEN LONGITUDINALLY (S-S), THE NECKS OF THE THIN FILAMENTS OF MYOSIN (N) ARE DISTRIBUTED ALONG THE WHOLE MYOSIN AXOSTYLE (B) IN THREE SPIRALS. C) THE MYOSIN AXOSTYLE (B) ORIGINATES FROM THE M LINE (M) AND IS ANCHORED TO THE Z (Z) DISC BY THE TITIN FILAMENT (TT). ON THIS THE NECKS OF MYOSINES (N) ORIENT THE SPIRALS OF MYOSIN HEADS (H) TOWARDS THE ACTIN FILAMENTS (A).

MYOSINE FILAMENTS

Myosins are filamentous proteins consisting mainly of three parts: 1) a globural terminal called the "head" (h1 and h2 in Figure 2.A), in which there are proteolytic and hydrolytic enzymes capable of attracting and destroying ATP; 2) a short extension called the "neck" (n1 and n2 in Figure 2.A), in which there are two sections, one able to bend and one to extend; 3) a long filamentous end called the "tail" (t1 and t2 in Figure 2.A) which extends by twisting on itself. Myosins are proteins sensitive to electrostatic variations in the environment in which they are present. In an electrostatically controlled environment, the elastic necks are folded and the heads tilted, while in the electro-active environment of the sarcoplasm, the necks lengthen and the heads are straightened. In the sarcomere the myosins come together to form thin filaments and thick filaments. Two myosins that join their tails in a long double-helix protein complex form a thin filament (Figure 2.A). In a human sarcomere there are more than 300 thin filaments which, symmetrically organised in two equal parts, join along the M line to form a thicker myosin filament. On each side of the M line, twelve triplets of thin filaments are arranged on two hexagonal bases of equal size and perfectly out of phase with each other (b1 and b2 in Figure 2.B), so that the molecular tails are intertwined to form a tubular protein structure, on which the elastic necks fold and the globular heads emerge. Seen transversely, the central body of the thick myosin filament has the shape of a twelve-pointed star, on which the thirty-six pairs of myosin terminals are aligned, and pointing in the direction of the nearest filaments of actin[3]. Viewed longitudinally, the filament often presents the myosin heads aligned along three spirals (SS section in Figure 2.B) starting from the M line and, each one twisting about 4 times, ending up in the direction of the extremities of the sarcomere[4]. The thin filaments of myosin are thus encapsulated to form an axostyle (B in Figure 2. A-B-C), a rigid mechanical organ placed in the innermost and central part of the sarcomere, along its longitudinal axis, with the ends suspended in the sarcomeral gel by titin protein filaments (TT in figure 2. A-B-C).

Titin, or connectivin, is a long tensile filament inserted concentrically into the tubular section of the axostyle, which extends from the M Line (M in Figure 2.C) to the Z Discs (Z in Figure 2.C) and acts as a beam carrying the whole complex of myosin protein tails. Mechanically, the axostyle is formed by the union of the two semi-axes of thick myosin filaments, which start from the M line grouping only the proteinic tails of the thin filaments (N in Figure 2.C) and stretching towards the extremities grouping the heads (H in Figure 2.C) of myosin proteins as if they were the cogs of three spirally wound gears.

ACTIN FILAMENTS

The actin protein filaments consist of two polymer chains, called F-actin (fibrin actin), which intertwine to form a double helix, very similar to that of DNA. Each protein unit of F-actins is a monomer (the single part of a polymer) called G-actin (glomerular actin), an agglomeration of ten layers of molecules crushed and curved in on itself like a boxing glove. On the lateral and inferior surfaces of the G-actins there are four anchoring sites, two for the adjacent monomers, the one before and the one after the same polymer, and two for the monomers which protrude from the second polymer of the helix[5]. On the central surfaces and internal G-actin there are respectively two receptor sites for calcium and magnesium ions and an attraction site for phosphates, where the ATP is captured and hydrolysed in ADP. Just as a boxing glove can be tightened, opened and turned, the G-actin can take on three forms: open and closed, when oriented in the direction of the neighbouring myosin heads and respectively shows or hides the phosphate sites, or the blocked form when it closes and rotates to move away from the field of attraction of the myosin heads[6].

Because of its floating nature, the double helix of F-actins is reinforced by two supporting protein nubs (Figure 3.A). Two filaments of tropomyosin proteins, interspersed with some troponin proteins, follow the spiral-like evolution of F-actins, making up the peripheral support nub7. A large filament of nebulin is interposed to the two F-actins to form the central nub that allows them to anchor itself to the Z Discs and remain suspended in the sarcoplasm parallel to the myosin axostyle. The free end of the nebulin, which terminates with a large tropomodulin molecule, avoids the unrolling and shrinkage of the double actin helix during sarcomeral contraction and allows the repositioning of actin filaments in their initial orientation at the end of the contraction[8].

THE ACTIN-MYOSIN COMPLEX

In a muscle cell, each thick filament of myosin is surrounded by six thin filaments of F-actin arranged on a hexagonal base and, in the case of sarcomeres with more myosin-like stomas in parallel, each thin filament of F-actin is shared by three thick filaments. Following the nerve stimulation of the muscle fibre, each calcium ion free to circulate in the sarcomere binds to a troponinic protein and alters the electrostatic balance of a short tract of tropomyosin, sufficient to modify the form of seven monomers of G-actin[7]. The G-actins are unblocked and aligned to the nearby myosin heads (Figure 3.B). If the myosin heads are joined to an ATP molecule, the electrostatic attraction they receive from the internal G-actin site is so high that it allows to change the state of G-actin, from closed to open, in order to join the myosin terminal, hydrolise the phosphate inside it, give it the strength to change its inclination and, finally, extend its elastic neck to the point where the extension allows its detachment. The whole sequence of these molecular reactions is called

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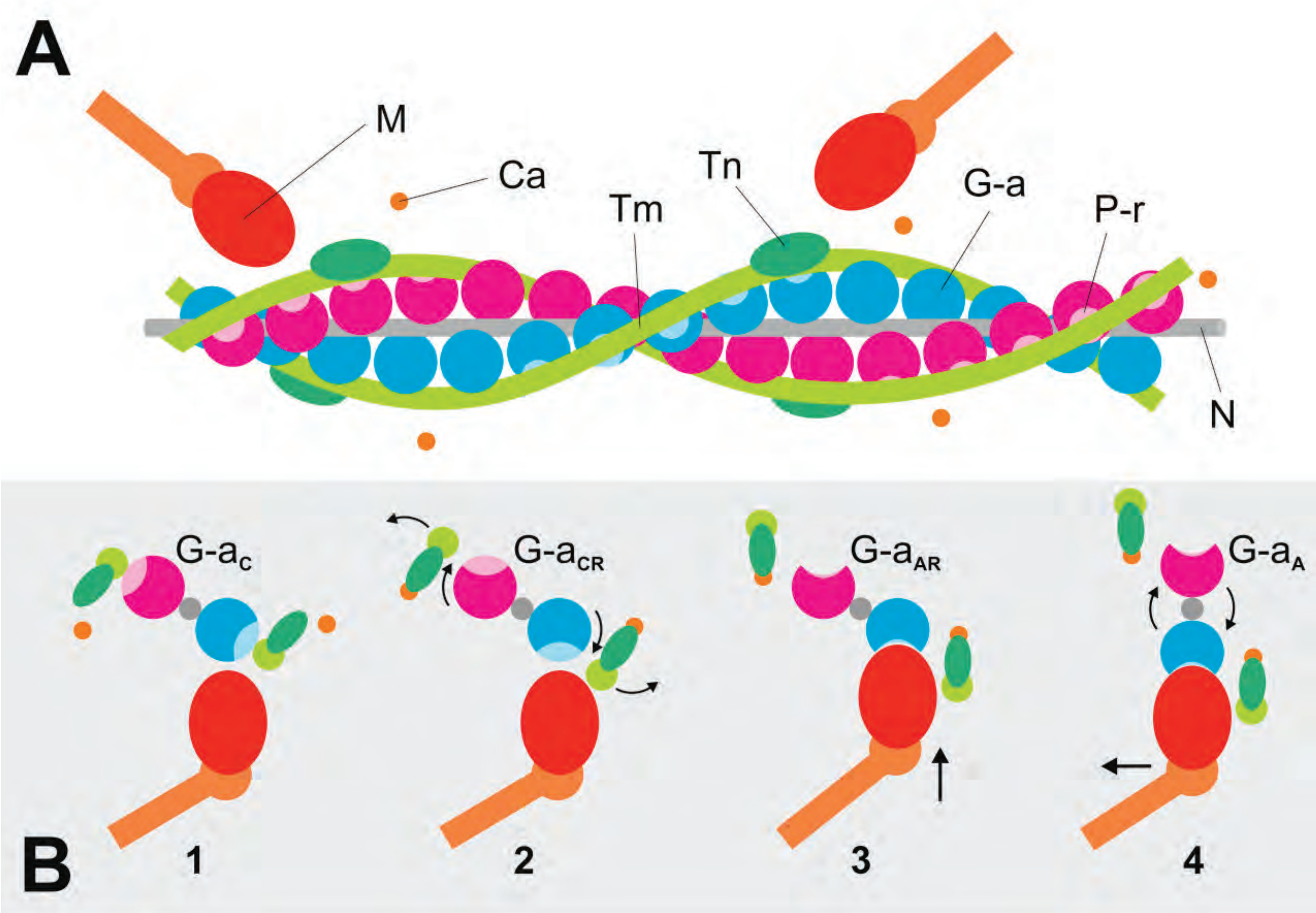

Figure No. 3

Graphical representation of the double helix of an actin filament.

A) Two G-actin polymers (G-a), called F-actins, are wrapped along a thick filament of nebulin (N). Two long filaments of tropomyosin (Tm) cover the phosphate receptor sites (P-r) of the two F-actins. B.1) In a state of rest, the G-actins of two adjacent polymers are aligned with each other (G-aC) and far from the adjacent myosin terminals (M). B.2) When calcium ions (Ca) are combined with troponin (Tn), tropomyosin uncovers the receptor sites of the G-actin phosphate that rotate (G-aR) in the direction of myosin. B.3) Under the influence of the myosin heads, G-actins open their phosphate receptor sites (G-aAR), allowing the actomyosin bridge to be realised. B.4) The electrostatic reactions characterising the actomyosin bridge return the G-actins (G-aA) in alignment with each other, predisposing them to a new cycle of activity.

an actomyosin bridge and generates the contracting force of the sarcomere.

The first explanatory model of the actomyosin bridge was described in 1957 by Nobel winner, Andrew F. Huxley[9]. His first X-ray observations, had identified the elastic function of the neck of myosin in allowing the head to flow linearly along the axis of contraction. (Figure 4.A). After approximately ten years of study and research, a scientist of the same name, Hugh E. Huxley, studied a new model, noting the importance of the inclination of the myosin head in the production of sliding force (Figure 4.B) [10]. In the early '70s, Andrew F. Huxley presented an update to the actomyosin bridge model proposed by his colleague Hugh Huxley, in which he characterised a rolling of the myosin head on four points of the contact area of actin: the first, with a weak attraction force, to combine myosin with actin, the second and third of a higher attraction force, to generate the sliding, and the last of a more short-lived force to favour its detachment (Figure 4. C)[11]. It was not until the 1980s that a study of the sub-atomic behaviour of the actomyosin bridge, and the introduction of the high-resolution electron microscope came about. In the last decade of the twentieth century, it was therefore possible to observe the role of ATP in the generation of the "power stroke" that the head of myosin is able to discharge on G-actin when it bends (Figure 4.D)[12, 13]. In the new millennium, thanks to the development of bio-informatics and computer graphics, the actomyosin bridge model was developed in 3D (Figure 3.E). The triple spiral of the thick myosin filament, hypothesised in the '70s[14], was confirmed in its geometric form4 and in its function as a motor of the double helixes of actin[15]. To date, after 60 years of studies, it is possible to demonstrate the biomechanical characteristics of the actomyosin bridge hypothesised by Sir Andrew F. Huxley[16].

The way in which myosin filaments transfer force to actin helixes continues however to be studied by the scientific community. During a contraction, all the myosin heads move in a synchronised manner in the direction of the nearest G-actins which they join up with[17]. Following the hydrolisation of ATP in ADP, the myosin heads move the G-actins radially and longitudinally, creating a rotation of the entire double helix of F-actins[18]. The force produced by the acto-myosin bridge is therefore three-dimensional: a longitudinal component that brings together Z Discs, a radial component that rotates actin filaments and a torsional component that compresses the entire structure of myosin[19].

From a mechanical point of view, the myosinic axostyle is comparable to a stator, a mechanical or-

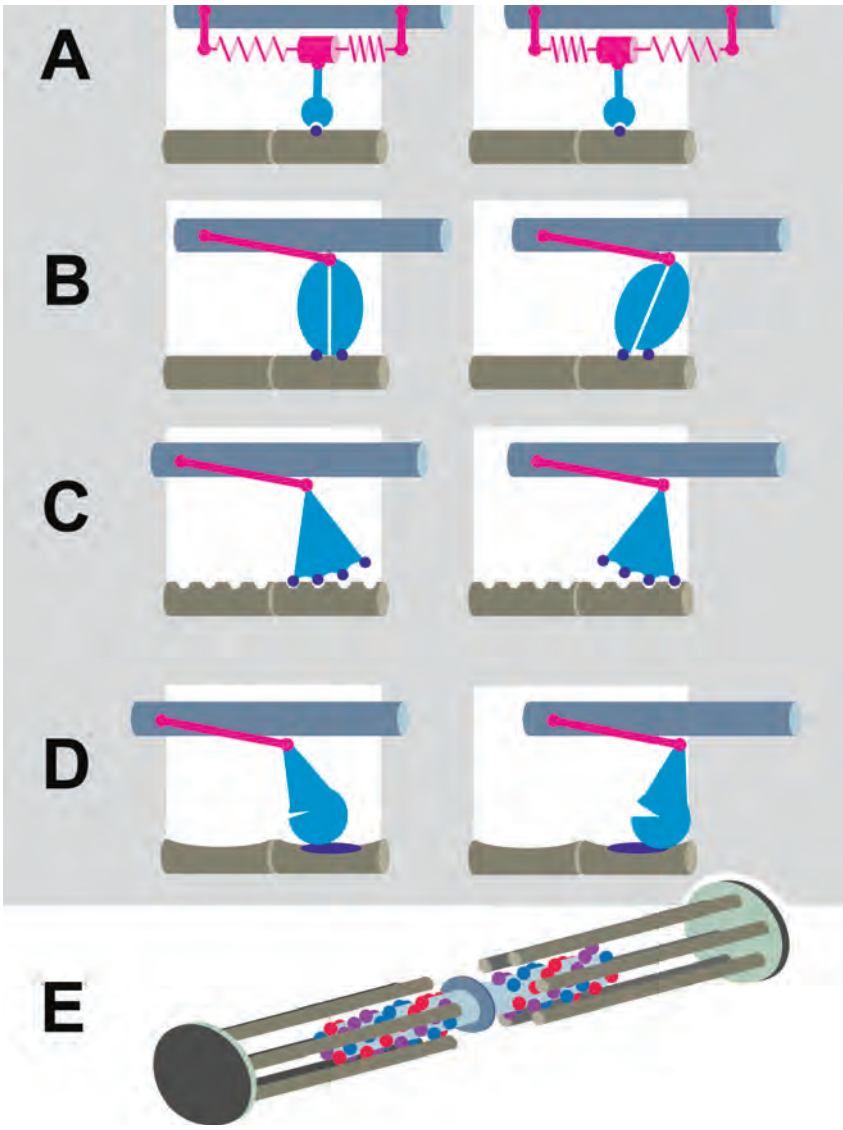

FIGURE NO. 4

MODELS OF ACTOMYOSIN BRIDGE.

IN THE DARK AREA OF THE FIGURE, THE SQUARES ON THE LEFT SHOW THE FIRST PHASE OF THE ACTOMYOSIN BRIDGE, WHEREAS THE SQUARES ON THE RIGHT SHOW THE FINAL PHASE. THE THICK FILAMENTS ARE AT THE TOP OF THE SQUARES. THE MYOSINIC NECKS ARE DEPICTED IN MAGENTA, THE MYOSIN HEADS IN CYAN. F-ACTIN FILAMENTS ARE AT THE BOTTOM OF THE SQUARES, FORMED BY TWO G-ACTINS. THE ELECTROACTIVE SITES ON WHICH THE ACTOMYOSIN BRIDGE IS FORMED ARE IDENTIFIED IN BLUE. A) 1957 AF HUXLEY MODEL, CHARACTERISED BY THE ELASTIC PROPERTIES OF THE NECK OF THIN MYOSIN FILAMENTS. B) 1969 HE HUXLEY MODEL, SHOWING THE CHANGE IN SHAPE OF MYOSIN HEADS DURING THEIR INCLINATION. C) 1971 HUXLEY & SIMMONS MODEL, WHICH HIGHLIGHTS THE SLIDING OF THE MYOSIN HEAD ALONG FOUR DIFFERENT SITES OF CONTACT WITH ACTIN. D) 1993 RAYMENT I ET AL. MODEL, WHICH SHOWS THE SITE WHERE PHOSPHATES ARE HYDROLYSED IN THE MYOSIN HEAD. E) 3D SARCOMERAL MODEL BY SKUBISKZAK L IN 2011, IN WHICH THE MYOSIN-LIKE AXOSTYLE IS ENVELOPED BY THE THREE SPIRALS OF MYOSIN HEADS.

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gan that does not rotate[4], despite the application of a torque. Thanks to the titin bands inserted in the central cavity of the thick myosin filament, the forces that twist the internal parts of the contracting sarcomere are discharged on the M line. The myomasin protein, which forms the filamentous network of the M line, has specific connective and elastic properties that guarantee, at the same time, the anatomical continuity and the mechanical discontinuity of the two thick filaments of myosin. Mechanically, the M line can be compared to a friction pad which allows to couple two distinct contractile force generators without any shear, compression and torsion forces compromising the structural stability of the entire sarcomere[19].

THE HALF-SARCOMERE

From the description of the biomechanics of the sarcomere illustrated so far, it is legitimate to state that the functional unit of the muscle is not the entire sarcomere, but one of the two halves that constitute it, in other words, a hemi-sarcomere that originates from the M Line and ends on a Z Disc20. Therefore, two hemi-sarcomeres symmetrically placed along the longitudinal axis and joined on the M line, form a sarcomere. The asymmetric contractile structure of the sarcomere was already observed in 1966 by Gordon AM, but with the aim of presenting an overall model of muscular mechanics, the study group he conducted chose to interpret the sarcomere as a single contractile unit[21]. However, if we consider the M Line as the place where the approach forces of the Z Discs are canceled during contraction, then a hemi-sarcomere shortens or extends if the external forces applied to its Z Disc are respectively higher or lower than those of the sole portion of sarcoplasm that belongs to it[20]. After repeated events in which the sarcomere is strongly stimulated to stretch, its contraction may turn out to be non-uniform and only one of its two halves can begin to shorten, while the second continues to contract isometrically. This situation is associated with popping sarcomere, a phenomenon of biological degradation that occurs when the two hemi-sarcomeres behave differently[22]. During an isometric contraction, for example, the two halves of the same sarcomere can manifest different behaviours, ranging from the case in which the whole myosin axostyle slides to one side of the sarcomere without the sarcomere's length changing, if the axiom remains in a central position resisting the external forces[23]. The myosin axostyles tend to move to one side of the sarcomeres when the muscle is strongly stimulated by intense passive eccentric exercises. Under these conditions, the heads of myosin of the stretching hemi-sarcomere come into contact with the F-actins of the shortening hemi-sarcomere, generating an isometric over-contraction equal to 190% of the force that an entire sarcomere can produce in maximum shortening. This non-uniform behaviour of the sarcomere serves to make it more resistant to the extra-maximal pulling forces that solicit it externally. Therefore, a sarcomere, inserted in a series of other sarcomeres and belonging to a single muscle cell, is able to regulate its overall contractile force through the independent contribution of each of its halves.

By means of the biomechanical model of the coupling of two independent contractile devices, the pair of hemi-sarcomeres symmetrically arranged on the same main axis, it is possible to explain how the sarcomere is the most efficient biological transducer, able to transform chemical energy into mechanical work. The (bio) technology that characterises the force production of a sarcomere is very similar to that of a self-locking linear differential.

THE SELF-LOCKING LINEAR DIFFERENTIAL

The linear differential is the mechanical device mounted, for example, between the rear wheels of a car, preventing the vehicle from losing grip on the asphalt while swerving. In order to keep the vehicle stable around a bend, the linear differential automatically and passively divides the traction of the engine; the wheel closest to the centre of the curvilinear trajectory slows down, and the furthest away moves faster. The linear differential consists of two concentric half-shafts coupled to each other with different planetary gears that rotate in parallel with the drive shaft and allow the drive torque to be distributed along two separate drive shafts, one for each drive wheel. When one of the two shafts is blocked, the free one rotates at a double speed without disperse driving torque.

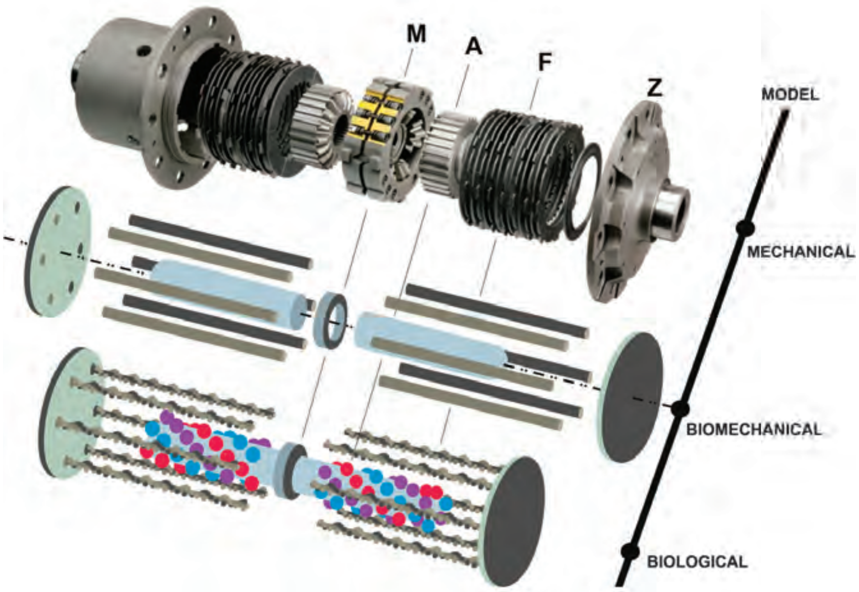

Figure No. 5

Comparative diagram between mechanical and sarcomeric differential systems. In this diagram, the components of a self-locking linear differential (BM237-HA Super Lock LSD mounted on BMW 4x4 models produced by OS Giken, Torrance, CA, USA), are compared with the components of a sarcomere. Along the comparative axis of the mechanical-biomechanical-biological model, it is possible to observe the functional congruences between the two biaxial (semi) rotary mechanics. Along the comparison M line, the fixing ring of the mechanical model, with its satellite wheels, is related to the central collector of the two axles of the biomechanical model, represented by the M line of the biological model of the sarcomere. Along the comparison A line, the semi-axes of the mechanical model are compared to the axostyles of the biomechanical model, consisting of thick myosin filaments in the biological model. Along the comparison line F, the planetary rings of the mechanical model are compared with the set of sliding axes of the biomechanical model, realised by the actin propellers of the biological model. Along the comparison Z line, the plates which anchor the rotating mechanical device to the driving shaft of the mechanical model are compared to the terminals of the biomechanical model and to the Z discs of the biological model of the sarcomere.

Self-locking differentials are an evolution of linear ones and serve, for example, to move the arms of industrial robots. They are called self-locking because they have a limit of rotations within which the servomotors act in precision, to produce continuous rapid movements, and beyond which they act in power, to lift and move very heavy objects. In precision robotics, such as gripping heavy and fragile objects, the self-locking devices are deactivated and the rotations of the transmission shaft are regulated by the differential planetary gears, which make it possible to modulate a progressive, continuous and gradual driving force on the entire mechanical arm. Once the object is gripped, the differential locks the two traction shafts together and begins to deliver maximum driving force in order to keep the robot's grip firmly, counteracting the counterweight generated by the manipulation and repositioning actions, without damaging the object being carried.

THE BIOLOGICAL MODEL OF THE SELF-LOCKING DIFFERENTIAL

During contraction, the two halves of the sarcomere have different and independent dynamics[24] so as to be able to correctly apply the model of the self-locking differential (Figure 5). If one side of a sarcomere is blocked by a constraint force, for example due to a voluntary joint stabilisation or a strong plyometric impact, then the central axostyle behaves as a stator and uses the forces that twist it to rotate the F-actin filaments and cause the unblocked extremity to shorten at a higher speed, avoiding loss of driving torque and contraction force. The centre of the sarcomere moves towards the blocked side until the two myosin shafts, when reaching the maximum shortening of the sarcomere, behave like a self-locking complex, ending their stroke, but continuing to generate force that will help to keep the entire structure of the sarcomere rigid until contraction ceases. This occurs when the sarcomere is inserted into a series of other sarcomeres near a

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muscle-tendon junction, a connective adhesion or other connection to a myofascial lining. When the whole series of sarcomeres is activated, there is a reciprocal exchange of contraction forces for which the shortening of one sarcomere becomes a source of external traction of the adjacent sarcomeres.

APPLICATIONS

The continuous scientific investigations into the muscular contraction biomechanism always provide new and interesting applications in the fields of bioengineering, for the technological progress of human-machine interfaces, and for the applied sciences of physical exercise, for the refinement of programmes aimed at improving sports performance and the quality of life.

After carefully analysing the biomechanical contractile units of the human body, in 2014, RISE Robotics (Massachussets, USA), a leading American company in the bioengineering sector, launched on the market a series of mechanical actuators that emulate muscle contraction using the technology of the self-locking linear differential. Their studies have shown that, via a self-locking linear differential, it is possible to apply a constant force on a robotic arm for its entire movement, unlike a classic motor gear. The company patent has been filed under the name Cyclone and is part of the Exosuit project (Figure 6.A) the purpose of which is to build wearable exoskeletons to provide human beings with hyper-force and the possibility to integrate their anatomical limits. The inside of the Cyclone has the characteristics of a hemi-sarcomere (Figure 6.B). A central axostyle (M in Figure 6.B), similar to that of the thick myosin filament, lateral rotors (A in Figure 6.B), such as G-actins, a mobile end (Z in Figure 6.B), similar to the Z disc, and a fixed one, like the M line (L in Figure 6.B). The big difference between Cyclone and a hemi-sarcomere is that the force transferred from the central rotor to the cursor is transmitted by the tensile force of a cable (C in Figure 6.B), rather than the tensile force of a calcium ion stream.

In a comparative analysis of the literature in the exercise sector, it was observed that the sarcomeres of the vast lateral quadriceps femoris significantly modify the way they generate force, depending on whether the exercise is a simple squat, a squat jump, a counter movement jump, or a jump from a raised surface.[25] In the latter jump, compared to the simple squat, the sarcomere is shortened with almost double the speed, producing a contraction

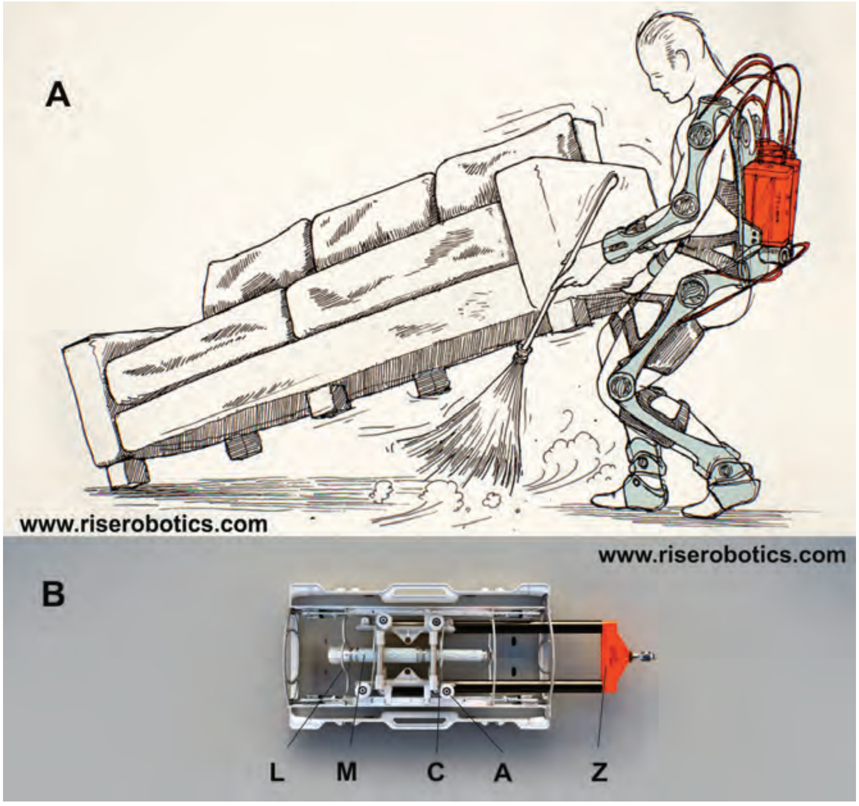

Figure No. 6
Bioengineering application of the linear differential models of sarcomere contraction.
A) Exosuit project by RISE Ronotics (Massachussets, USA), an exoskeleton capable of transferring a hyper-force to the human limbs produced by mechanical actuators inspired by sarcomeric biomechanics. B) RISE Cyclone Project Ronotics (Massachussets, USA), a force actuator that emulates the technology of a hemi-sarcomere. A central axostyle (M), similar to the thick myosin filament, is held in place by an anchor line (L) similar to the sarcomeral M line. Some peripheral rotors (A) which, as the actin filaments do with the Z discs, move the mobile end of the actuator (Z). The great difference between the Cyclone and a hemi-sarcomere lies in the type of force useful for the traction of moving parts: in the former it is mechanical tension, whereas in the latter the tension is electro-ionic.

force of less than 25% and a consequent reduction in power. To justify an increase in contractile velocity at the expense of the force produced, the authors considered, among other hypotheses, the differential interactions of the hemi-sarcomeres. But it is when performing movements that stretch the muscles to their fullest extent that the differential self-locking behaviour of the sarcomeral contraction manifests itself. In fact, it would appear that high impact active stretching exercises, in which the tendons elongate more than 5 mm while the muscles contract isometrically for more than 5s, make the sarcomeres contract in a non-uniform manner. The consequences of this asymmetric contraction strategy make the muscle unable to produce maximal force peaks up to 2-4 hours after exercise, with a further reduction in strength over the next 24 hours. This information should be taken into account by coaches and athletes when planning afternoon sessions of explosive or maximal strength, after active stretching sessions in the morning or afternoon of the previous day. Finally, it is important to remember that all muscles engaged in generating force during their elongation, in the phases of landing after an elevation, in the braking phases after a run, in direction changes and deceleration of overloads, are subject to non-uniform contractions.

FINAL CONSIDERATIONS

The study of sarcomere functions using the differential model allowed to identify the smallest cell sub-units of muscle tissue that have independent contraction abilities in the two halves of the sarcomere. However, with this type of model it is essential to remember on which dimensional scale the sarcomere contracts and its parts twist. The intensity of the mechanical power delivered by the sarcomere has nothing to do with that produced by engines designed to move cars or prehensile devices used in robotics. The phenomenon of sarcomeral contraction, seen on a molecular scale, is linked to the nanoscopic distances that exist between the molecules and not to the velocities with which the forces are produced. In fact, a sarcomere in conditions of rest is on average 2.5 μm long and, with an A band of 1 μm and two I bands of 0.75 μm each, it can contract up to 1 μm and extend to 4.0 μm, maintaining a constant transversal diameter of about 1m. From the position of extreme stretching to that of extreme shortening, the sarcomeric flows for 3m using approximately 200 ms at a speed of about 1 mm per minute, with its internal structures twisting at a radial velocity of 0.017 rad/s, using that is, about 370 s to complete a complete rotation on its own axes[27]. Seen on a dimensional scale perceptible to the human eye, a sarcomere is shortened in a very short instant only because its length is infinitesimal. If the muscle fibres were made using a few long (in centimetres instead of micrometres) sarcomeres in a row, the muscles would have been very slow to contract!

ABSTRACT

During muscle contraction, calcium ions enter the sarcomere, bind to troponin, which moves the tropomyosin filaments, to allow the actins to join the mobile terminals of myosin and produce the shortening of muscle fibre. Over the last 60 years of biological research, various biomechanical models have been presented to describe these rapid sequences of molecular actions and reactions. It is a well known fact how the entire sarcomere transforms its chemical energy into mechanical contraction energy. However, how the sarcomere is able to partition this mechanical force at its extremities, it is still the object of study.

The aim of this article is to illustrate the most modern theories on the biomechanical model of sarcomeral contraction, taking inspiration from the concepts of hemisarcomere and self-locking linear differential. According to these theories, the contraction of the muscular cell is a sum of biomechanical phenomena that are independently generated in the two sides of the same sarcomere.

These concepts, in addition to inspiring the development of innovative biotechnological applications to allow humans to experience hyper-force, they explain some of the abnormal physiological responses that muscle tissue manifests after being stimulated by intense eccentric exercises.

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THE PNEI, PARADIGM FOR SPORT

PART ONE

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INTRODUCTION TO PNEI

Psychoneuroimmunology (PNEI) is a "molecular-based systemic discipline" that was officially born in 1981 with Robert Ader's book Psychoneuroimmunology, which highlighted the relationship between the nervous system, immune system and behaviour, showing in mice, following Pavlovian conditioning (a sugar cube with an immunosuppressive), how a nervous stimulus could depress the immune system. Thanks to the discovery that cells differentiating by phenotype can respond to and secrete the same molecules (neuro-peptides, hormones or cytokines), in the last 40 years, biological communication pathways have been defined between the psyche, the central, peripheral, autonomic and enteric nervous systems, immunity, endocrine glands, microbiota (intestinal and not only) and, last but not least, the myofascial system (Bottaccioli & Bottaccioli 2017; Chiera et al., 2017).

PNEI, therefore, evolving the acquisitions of the biopsychosocial paradigm of Engel, studies the bidirectional relations between social environment, psyche and biological systems, describing how the psyche is capable of modulating the functioning of the organism up to gene expression (the epigenetic effect) and explaining how the biological order modifies thought itself. PNEI is responsible for understanding, based on the careful study of pathophysiology, also and above all, at the molecular level, how people respond to environmental stressors, be they psychological or physical (Bottaccioli & Bottaccioli 2017).

The "essence" of PNEI is, in fact, the stress reaction or, as defined by the Austrian physician Hans Selye in 1936, a "syndrome of general adaptation": the organism's response to environmental challenges through variations of its functions, so as to fight or run away in the short term, and survive better in the long term. If, on one hand, the organism on a daily basis aims at maintaining its vital parameters considerably stable (in particular O_2, pH and temperature, although it would be interesting to evaluate the systemic effect of slight changes, perhaps induced spontaneously), on the other, it must be able to change its own balance, the level of its own parameters, to define a new set points, to remember the challenges already faced and foresee new ones: it must, in other words, go from a condition of homeostasis, in which it survives while remaining the same, to one of "allostasis" in which it survives, adapting and reaching a new balance (Sterling 2012).

By its nature, therefore, PNEI opposes the reductionist paradigm that dominated the West at least until the 1950s, yet still present in many scientific and non-scientific circles, which denies the relevance of "emerging" properties (e.g. it considers the psyche incapable of providing feedback to the body) and whose purpose is the reduction of the complexity of reality to specific ultimate determinants of physical or physical-like nature (such as genes, atoms, quarks, etc.) (Bottaccioli & Bottaccioli 2017). In the medical-health field, reductionism has led to the radicalisation of the diagnosis process and the choice of increasingly specialised therapies, so as to "mechanically" identify and organise, in the wake of the metaphor "body = hardware and psyche = software", the individual factors determining health and disease. Unfortunately, this resulted in a health system crisis for several reasons: the huge increase in costs; the low level of satisfaction expressed by patients and insiders; an increase in medical errors; an increase in disparities in treatments; a reduction in the quality of clinical outcome (Fani Marvasti et al., 2011).

PNEI AND PHYSICAL ACTIVITY

If we consider physical activity, primarily as continuous training, we realise that it is an allostatic adaptation (Li & He 2009): in fact, athletes continuously vary the set points of their cardiovascular, respiratory and metabolic system, but not only. It is a 360° psychoneuroendocrinoimmune adaptation (e.g. physical strength does not increase primarily because the muscles become hypertrophic, but because there is a reorganisation of the neuromotor plaques and brain areas related to the muscles and exercises, Enoka 1997) and as we will see in the following paragraphs, many factors act on this.

Every athlete knows very well the importance of "predicting" their own performance, that of others and what will happen during the performance to anticipate any "challenges" or "obstacles", as well as the need to "harmonise" the physiological and psychological adaptations, to have a "healthy mind in a healthy body". And just as every athlete knows the pro-

blems of overtraining, so too in pathophysiology can we talk about "allostatic load", in other words, the state the organism enters into when the cost of its adaptation strategy to internal demands (e.g. performance anxiety) and inflammatory diet) and external (e.g. social pressure, over intense training) start to outweigh the benefits: in this case, the body is less capable of appraising and coping, leading to damage to the psychophysical health and the possible manifestation of real pathologies (McEwen & Gianaros 2011). In fact, as already stated, the stress reaction of the organism is a 360° response that involves every single tissue: if, thanks to Selye's research, we know that, centrally, everything starts with the hypothalamic-pituitary-adrenal axis (or HPA axis), therefore, as a result of information received from inside the body (interoception) and from the environment (exteroception), the paraventricular nucleus (PVN) of the hypothalamus induces the hypophysis to stimulate the cortex of the adrenal glands to release cortisol. Research in the last 80 years has shown that hypothalamic activation is only the last stage of a complex and continuous elaboration of the whole brain (cortical and subcortical areas) (Steimer 2002). The neurovegetative system is involved, not only with the increase of metabolism, but with the modulation of immunity: the catecholamines secreted by the orthosympathetic division can increase the inflammatory levels (Elenkov 2008), while the collaboration of the vagus and orthosympathetic nerve in the reflex anti-inflammatory cholinergic induces the decrease of inflammation (Boeckxstaens 2013). We also know that the activation of the HPA axis has repercussions on all other endocrine axes (thyroid, sexual glands, etc.), in addition to this, stress hormones and neuro-transmitters are not only received, but also produced by virtually every cell, with the result that every tissue (connective, understood as fascia and bones, and muscle included) has its local stress reaction, which influences the neuro-endocrine-immune status of neighbouring tissues, in a mutual interdependence with the state activation of the central HPA axis (Chiera et al. 2017).

Let's now go into the details of this interdependence, initially addressing the topic of posture and then moving on to the links between sports performance and muscular neuro-endocrinology, nutrition and biological rhythms.

THE BIOTENSEGRITY MODEL OF POSTURE

Today the biotensegrity model is the most comprehensive and complex paradigm used to explain kinetics and human postural statics. The tensegrity model was created in the field of architecture by B. Fuller and his student K. Snelson, the creator of "energetic geometry". Fuller, the father of tensegrity, by observing the forms present in nature, noted that the same were finite systems of energy, given by the simultaneous action of tensive and compressive forces, where the behaviour of a system is not the result of the sum of the single parts, but of their interactions (Scarr 2014). Snelson, on the other hand, created the first stable tensile structures thanks to the distribution and balancing of forces over the entire structure, thus able to adapt effectively to mechanical stressors (Ingber 2003).

The first to apply these concepts to the human body was Stephen Levin, an orthopedic surgeon. In 1975, not convinced by the answers provided by the compression model and levers, in relation to the observations made in the paleontological field on the skeleton of dinosaurs, Levin coined the term "mesokinetic": the motion of bodies derived from the tissues deriving from the mesoderm, such as the fascia. Going beyond the paradigmatic division of bones, muscles and connective tissue, Levin described the mesokinetic system as an entity in which the laws of tensegrity can be applied (Scarr 2014). According to this model, the bones represent the rods of Snelson's sculptures, while the myofascial system represents the wire (Ingber 1998): this also explains the stabilisation of "hanging" structures, such as the upper limbs or the jaw (Levin 2002).

Mesokinetics has provided a theoretical substrate for myofascial chains, which can be described as mechanical continuity circuits that guarantee coordinated movements with low energy consumption (Swanson 2013). It follows that, by applying biotensegrity to myofascial chains, we finally have a model that integrates each part of the body into one, effective, coherent unit (Ingber 2008). The constant tension of the tissues, combined with the neuromuscular junctions, allows a quick response to proprioceptive stimuli and those deriving from the central nervous system. This explains why bodily alterations, incorrect posture, the presence of lesions or tissue scars modify the tension balance of the body, jeopardising the functionality of the body (Ingber 2008).

It is obvious that Levin's model clearly opposes the paradigms that reduced the complexity of the "posture" phenomenon to biomechanical models, aimed at identifying and correcting the receptor, the root cause of postural problems.

BIOTENSEGRITY AT CELLULAR LEVEL

Snelson's sculptures also inspired the work of Donald Ingber (Ingber 1998), a Harvard professor emeritus, who applied the tensegritive principles at cellular level, in particular to the cytoskeleton, thus understanding that (Tadeo et al., 2014):

- microtubules are found in compression, like the rods of Snelson's sculptures, and move the nuclear membrane away from the cell membrane;
- the intermediate filaments and microfilaments are in tension, like the wires of Snelson's works, bringing the nuclear membrane closer to the cell membrane.

This allowed us to understand the three-dimensional and continuously changing structure of the cell (Lele et al., 2007) and to fully study the cytoskeleton function connected externally to the extracellular matrix (ECM) of the surrounding fascia by means of particular membrane proteins (integrins and caderins) (Stamenovic & Wang 2011), and internally in continuity with the chromatin. It follows that every movement of the body (articular or visceral) modifies the tension of the ECM which in turn, reshaping the cytoskeleton, changes the gene expression (epigenetic effect on a mechanical basis) (Swanson 2013).

In fact, with the birth of mechanobiology and the study of bi-directional interactions between biochemistry and biomechanics, scientific research can direct its focus on everything that is able to produce an effect on the fascia tension state: an example in particular which concerns the professional athlete is the role played by the HPA axis with its two main arms - nervous and endocrine.

The former, in fact, releases various inflammatory cytokines, including TGF-1, capable of transforming fibroblasts, typical connective cells, into myofibroblasts, in other words, cells capable of generating fascia tension over time. This contraction can mechanically stimulate cell receptors that will release larger amounts of TGF-1, thus leading to a vicious circle (Bhowmick et al., 2009). The endocrine arm of the stress axis also contributes to the increase of the fascia rigidity: in a chronic state, the catecholamines and cortisol actually induce the formation of more extensive fibrosis, tissue adhesions and scars, increasing the secretion of reactive oxygen species (ROS), genes (NF-Î°B) and inflammatory cytokines that stimulate myofibroblasts to produce collagen and contract. These strong contractures transfer mechanical strains that can be absorbed by integrins that alter cellular biochemistry, favouring further inflammatory phenomena (Tomasek et al., 2002).

With regard to posture, we can therefore conclude that the human being is composed of a single continuum, and the body is a hierarchical tensegritive system, from the intracellular level to the whole organism. Furthermore, with regard to kinetics, we know that mobility is transmitted to the whole system and that its energy is stored and released through the distortion and normalisation of the entire body form.

FASCIA, NERVOUS SYSTEM AND BODY-MIND INTEGRATION

Fascia contractures and inflammation can alter the nervous and mood information coming from the fascia tissue itself. We can understand what this alteration implies for the athlete simply by considering that the brain, at all times, creates maps of the state of the body, which not only allow the brain to understand what is happening, but exert a constant influence on the same body from which they originate (Damasio 2012). Moreover, according to the neuroscientific approach of the embodied cognitive science, the psyche and the brain can be understood only in relation to the sensory capacities and motor reaction of the organism (Gallagher & Zahavi 2008), and the presence in the myofascial system of sensory fibres and motor fibres according in 3:1 ratio, makes the fascia the largest sensory organ (proprioceptive and interoceptive) in the body (Schleip 2003). Most of the fascia receptors, which rely on slow type C fibres, are connected to the brain via the I-spino-thalamo-cortical lamina pathway, which shows a 7:1 ration between interoceptors and all the types of receptors. Interoception is "a personal experience of the body state" (Craig 2002), which correlates to many sensations: pain, medically unexplained and explainable symptoms, negative emotions, affective and anxiety disorders, regulation of emotions, meditation, decision making, self-awareness and conscience, subjective perception of time, eating disorders, water and food intake, sexual functions, empathy, hypnosis, etc. (Ceunen et al., 2016).

From the neurological point of view, the primary interoception starts at the back of the insula where the information, not yet conscious, passes to the insula media where it is integrated with the information coming from the secondary somatosensory cortex, the area that processes the proprioceptive, visual, auditory, vestibular stimulations and those arising from the hippocampus (memory) and amygdala (emotions). Finally, all this information passes to the anterior insula where integration occurs with the areas related to rationality and the subjective history of the person: anterior cingulate, orbitofrontal cortex, dorsolateral prefrontal cortex (Craig 2002).

In simpler terms: when athletes must make decisions and react, they are strongly influenced by the interoceptive and proprioceptive sensations coming from the fascia (Chiera et al., 2017). This is why it would be useful for specific loads to be used during work outs in order to train the correct body perception. It is clear that, based on the above, postural assessment becomes highly complex: the static and dynamics of an athlete are in fact influenced by lifestyle and the ability to manage stress in the more complex meaning of the term. It is no coincidence that scientific publications have been added in recent years that integrate the biopsychosocial and neuroscientific aspects of sport, highlighting, for example, that in order to perform specific movements and achieve high-level performance, all areas of the brain should work in an associated and optimal way (Nielsen & Cohen 2008) and not be "disturbed" by other tasks (e.g. processing nociceptive or inflammatory stimuli) (Puentedura & Louw 2012). In fact, in athletes with experiences of major stress, anxiety, depression or pain, there were changes in brain neurological networks resulting in inadequate decision-making: the same increase in emotional responsiveness, associated with an increased activity of the amygdala and the orthosympathetic tone, correlates with the reduction of focus areas and an increased risk of injury (Ivarsson et al., 2016).

NUTRITION AS AN ALLOSTATIC REGULATOR

Inadequate food strategies, which are not personalised to the needs of the athlete or based on "DIY" concepts can already predispose to the allostatic load. DIY nutrition in particular increases this risk because it often consists of the reckless use of unnecessary ergogenic (although effective in theory, their real effectiveness depends on the specific competition) (Naderi et al., 2016) if not harmful (e.g.: consuming only egg white induces the production of IL-1 and TNF, inflammatory cytokines) supplements (Andersen et al., 2014), especially in young athletes who are more sensitive to media pressure (Porrini & Del Bo' 2016). It is, in fact, young people who manifest side effects such as headaches, gastralgia, sleep problems, hyperactivity and risk of physical trauma, with all the behavioural consequences such as little sleep and a lower perception of fatigue that in turn prevents adequate rest (Visram et al., 2016).

Following a good diet (from the Greek, "life regime") does not only mean introducing macro- and micronutrients in the correct quantities to guarantee a good metabolism (certainly a fundamental objective), but also the intake of substances necessary to support the allostasis process in the body. In other words: we must consider the interactions that foods and nutrients (macro-, micro-, antioxidants, etc.) have with the immune system, the state of health of tissues such as the intestine, hormonal production, neurovegetative balance, and the mental state of the athlete.

In practice, during intense physical activity (at least 50-60% of VO2Max), catecholamines increase the intestinal expression of the sodium-dependent glucose co-transporter 1 (SGLT1), increasing the absorption of water, sodium and glucose (fundamental nutrients to support performance). At the same time, the myosin light chain (MLC) is phosphorylated, so that the intestinal epithelial cells can rearrange their cytoskeletons: the result is a slightly more permeable intestine that facilitates the passage of nutrients. At the same time, glucocorticoids increase the expression of NF-B, a nuclear transcription factor that initiates the production of inflammatory cytokines, while the orthosympathetic activation increases the body temperature and causes a vasoconstriction in the internal viscera, to direct the blood flow towards the muscles, heart and lungs (Clark & Mach 2016; de Punder & Pruimbroom 2015).

If such intense physical activity continues without adequate recovery, the consequences may be very significant: the intestine becomes more and more permeable, favouring the passage of toxins such as bacterial lipopolysaccharide (LPS) which, once absorbed by the immune system, stimulates a inflammatory response which, in turn, through the phosphorylation of the MLC and together with the increase in temperature and vasoconstriction by an orthosympathetic tone, increases intestinal permeability thus creating a vicious circle. One hour of cycling at 70% of the maximum working capacity or 70% of the VO_2max can cause hypoperfusion and damage to the small intestine. Moreover, this state of inflammation alters the composition of the intestinal microbiota, favouring a dysbiosis: a decrease in the microbes that produce substances useful to the body (e.g. butyric acid) to regulate immunity and maintain a healthy intestinal barrier, while increasing the microbes which release toxins (e.g. LPS), which alter the production of neurotransmitters such as serotonin, dopamine, neuropeptide Y (NPY) and gamma-amino-butyric acid (GABA), with intestinal (e.g. constipation) and mental (e.g. anxiety) repercussions. Dysbiosis and intestinal permeability are also risk factors for various diseases, including type 1 diabetes, multiple sclerosis, rheumatoid arthritis, chronic fatigue syndrome and depression (Clark & Mach 2016; de Punder & Pruimbroom 2015).

At the systemic level, as already mentioned, stress hormones affect the myofascial system, in particular the connective tissue. Stress in fact increases humoral Th2 immunity, inducing mast cell degranulation, the activation and tissue infiltration of macrophages, and above all neutrophils (Beiter et al., 2015), with the subsequent release of ROS, inflammatory cytokines (IL-1, IL-6 and TNF) and enzymes such as triptase, kinase and metal-proteinase (MMP) whose role is to degrade tissues (bones, muscles and fascia) (Caughey 2007).

If in the short term these events help an athlete to remodel his body (e.g. the muscles suffer small tears to make room for new fibres) and to protect themselves from possible wounds and / or infections, in the long run they cause loss of IIx and IIb fibres linked to muscular power (Shakman et al., 2013), an increased risk of fractures due to excessive bone

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reshaping (Yao et al., 2013), decreased neurotrophic growth factors (NGF, Kucharczyk et al., 2016), tendinopathies due to collagen degradation (Khan et al., 1999) and fascia tissue laxity, thus increasing injuries, reducing adaptive capacity and favouring inflammatory pathologies.

Appropriate nutrition for the individual athlete can prevent these negative consequences by supporting the allostatic adaptation capacity of each tissue. Let's take a look at some classic nutrients: Vitamin A supports the production of secretory immunoglobulins (SIgA); Vitamin D regulates immune responses; Vitamin E protects epithelial cells from ROS, in particular together with Vitamin C and polyphenols; zinc ensures good Th1 antiviral and tumour immunity, usually suppressed by physical activity (Metz 2003); magnesium and calcium regulate the neuro-muscular metabolism and act as anti-inflammatories (Calder & Kew 2002; Clark & Mach 2013; Mora et al., 2008).

Vitamin C, a fundamental component of collagen as it increases its melting temperature from 24°C to 42°C (Lieberman & Marks 2013) (although it is a hypothesis, it could therefore help to support the thermal stress from orthosimpatico), alongside carbohydrates and glutamine then supports Th1 immunity (Caris et al., 2014; Peters et al., 1993), thus preventing any infections, typically present in the respiratory tract of athletes (Metz 2003). These same nutrients, together with others already mentioned, such as vitamins A, E, zinc and N-acetylcysteine (glutathione precursor, one of the main antioxidants of our body), can also reduce the oxidising and inflammatory effect of neutrophils (Peake & Suzuki 2004 Popovic et al 2015). Fatty acids such as -3 (EPA and DHA obtainable from fish, in particular oily fish or small fish to avoid mercury pollution) mitigate intestinal inflammation and hypoperfusion damage (Clark & Mach 2016), as well as supporting hippocampal neurogenesis, neuro-plasticity and reducing neuro-inflammation in problems such as depression, Alzheimer's and neuro-psychiatric disorders (Crupi et al., 2013).

At a strictly intestinal level, given its often detected deficiency (Nikic et al., 2014), fibre (deriving from whole grains, legumes, nuts, vegetables) favour the health of the intestinal microbiota, increasing its biodiversity, the production of short chain anti-inflammatory fatty acids and the ability to resist pathogenic microbes. Together with the use of glutamine and probiotics (Lactobacilli and Bifidobacteria in particular) (Clark & Mach 2016) or fermented foods extracted from microbes (Selhub et al., 2014), fibre therefore helps to protect and restore the intestinal barrier and to regulate intestinal neuroendocrine production.

Lastly, even water is a vital nutrient to be regulated well: on the one hand, its non-intake or expulsion through diuretics in order to lose weight can lead to dehydration, thermal shock, metabolic regulation and cognitive alterations (Pococco et al. 2013); on the other hand, consumption that increases body weight during physical performance (e.g. marathons) can cause problems with hyponatraemia and water intoxication with possible convulsions (Noakes & Speedy 2006).

ABSTRACT

Psychoneuroendocrinoimmunology (PNEI) is a "molecular based systemic discipline" that studies the interactions between the body systems, between the body and the mind, between the organism and the physical and social environment, relying on the most recent research in neuroscience, molecular biology, epigenetics, and more.

Given the extreme variety and the substantial psychophysical load it imposes on athletes wishing to achieve the best results, sport is a complex phenomenon that deserves to be addressed in the most comprehensive way possible. Studying sports from the PNEI perspective allows us to understand how, in addition to the mechanics and the classic principle of every "use it or lose it" workout, multiple aspects influence the performance and the athlete's state of health.

Therefore, in this article we will show the connection, from a PNEI point of view, of sports performance with factors such as posture, muscular neuro-endocrinology, nutrition and biological rhythms.

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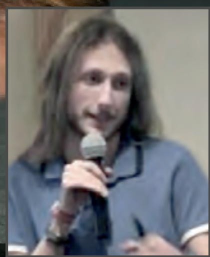

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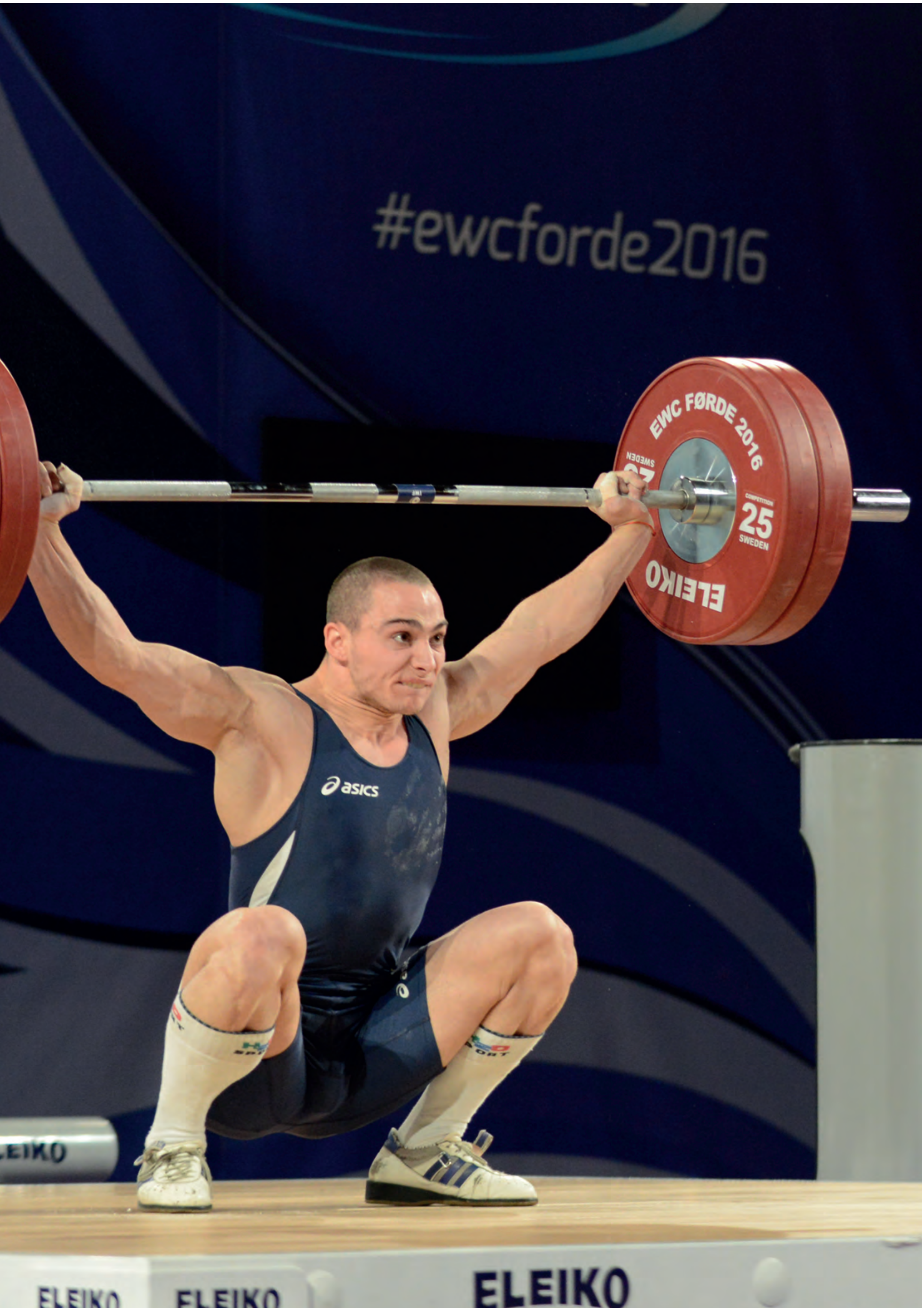
IDENTIFYING A TEST TO MONITOR WEIGHTLIFTING PERFORMANCE IN COMPETITIVE MALE AND FEMALE WEIGHTLIFTERS

BY S. KYLE TRAVIS , JACOB R. GOODIN, GEORGE K. BECKHAM, CALEB D. BAZYLER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1. INTRODUCTION

In weightlifting, as in any sport, monitoring and assessing an athlete's ability to recover and adapt is vital to ensure the athlete is prepared for competition [1]. Weightlifting performance depends heavily upon an athlete's leg and hip strength, which are important for generating large ground reaction forces in a short time frame [2]. While 1-repetition maximum tests are often considered the gold-standard for assessing maximal strength, it is impractical for weightlifters to regularly perform a 1-repetition maximum snatch or clean and jerk in training. Instead, dynamic and isometric multi-joint performance tests have commonly been used to monitor and evaluate weightlifters [3,4,5,6,7,8,9,10,11,12,13,14,15].

Vertical jumps have been widely used to evaluate general athletic ability [16] and are biomechanically similar to weightlifting movements [8,9,10]. Strong relationships between squat jump and countermovement jump (SJ, CMJ) along with snatch and clean and jerk performance scaled to body mass (BM; r = 0.72 to 0.76) have been observed in national level male and female weightlifters [8]. Similar results have also been reported in international level weightlifters, with strong relationships between SJ (r = 0.66) and CMJ (r = 0.75) and the Sinclair Total (ST) [7]. However, some of these studies used contact mats, possibly leading to lower estimations of these relationships compared to force platforms or motion analysis software [7]. Therefore, an analysis with more robust instrumentation is needed to confirm these relationships [17,18]. The isometric mid-thigh pull (IMTP) is a viable monitoring test for weightlifters because both the maximal force and rate of force development (RFD) can be derived from the resultant force trace. Both of these variables are strongly related to weightlifting performance and are sensitive to changes in training volume-load [12,13,14,15]. Beckham et al. [15] found strong relationships between IMTP isometric peak force (IPF) and allometrically scaled IPF (IPFa) with snatch (r = 0.83, 0.62), clean and jerk (r = 0.84, 0.60), and competition total performance (r = 0.84, 0.79, respectively). The Sinclair Total and allometric scaling of competition results also showed a very strong relationship to IPF and IPFa, suggesting that maximum strength is an important factor even when BM is accounted for [12]. Similar relationships between IPF and snatch, clean and jerk, and absolute weightlifting performance (r = 0.93, 0.64, and 0.80, respectively) were also reported in a group of elite female weightlifters [13].

Although the weightlifters in the aforementioned studies were considered elite, the generalizability of the studies' findings is limited due to small sample sizes (n 12). Considering the potential value of vertical jumps and IMTP as monitoring tools for weightlifters, further research is needed to examine their relationship to weightlifting performance in a larger sample. To the authors' knowledge, no studies to date have evaluated SJ, CMJ, and IMTP performance compared with absolute and scaled competition results in a large sample of weightlifters (n > 12). Therefore, the purpose of this study was to (1) determine the relationships between vertical jump, IMTP and weightlifting performance; and (2) compare vertical jumps to IMTP as monitoring tests of weightlifting performance in a large cohort of male and female weightlifters. We hypothesized that strong relationships would be observed between vertical jump, IMTP, and weightlifting performance in males and females. However, we also hypothesized that vertical jump performance would exhibit a stronger relationship than IMTP variables to weightlifting performance, and thus serve as a better monitoring test than IMTP.

2. MATERIALS AND METHODS

This retrospective study sought to evaluate relationships between performance monitoring data and competition results from a weightlifting competition in which all lifters achieved a competition total. All subjects completed performance testing which ranged from 7.0 ± 5.2 days (range 2–18 days for males and 2–11 days for females) after a competition for which they peaked. Post-competition testing was completed as part of a long-term athlete monitoring program during a 2.5-week active recovery period to allow time for fatigue to dissipate. This study was granted a waiver of the requirement to obtain informed consent by the university's institutional review board.

2.1. ATHLETES

A group of fifty-two weightlifters (31 males and 21 females) ranging from Level 1 to Master of Sport International Class participated in this study (Table 1). Within this group, there were national level (n = 20) and collegiate level weightlifters (n = 32), including weightlifters who compete at the International, Senior National, and Collegiate National levels. Each athlete's weightlifting performance was classified according to Takano's [19] classification system, from Master of Sport and below. According to each classification, the men and women were ranked accordingly: Master of Sport (n = 0 vs. n = 5, respectively), Candidate to Master of Sport (n = 9 vs. n = 6, respectively) and a range of Level 1, 2, and 3 individuals (n = 22 vs. n = 10, respectively) [19].

Table 1. Descriptive characteristics.

2.2. HYDRATION AND ANTHROPOMETRICS

Hydration status was evaluated prior to testing using a refractometer (ATOGO, Tokyo, Japan). Athletes were considered hydrated if urine specific gravity (USG) was <1.02. BM was measured with a calibrated digital scale to the nearest 0.1 kg (Tanita BF-350, Arlington Heights, IL, USA). Height measurements were assessed using a stadiometer (Cardinal Scale Manufacturing Co., Webb City, MO, USA) and recorded to the nearest 0.5 cm.

2.3. STANDARDIZED WARM-UP

Prior to testing, each athlete performed a standardized warm-up protocol of 25 jumping jacks, 1 set of 5 dynamic clean-grip mid-thigh pulls with 20 kg followed by 3 sets of 5 repetitions with 40 kg for females and 60 kg for males. Approximately 60 s of rest was allotted between sets.

2.4. DYNAMIC VERTICAL JUMPS

All unloaded vertical jump testing was completed with a near weightless polyvinyl chloride (PVC) pipe (<1 kg). Squat jumps and CMJ were performed on dual force plates (Rice Lake Weighing Systems, Rice Lake, WI, USA; 1000 Hz sampling rate) on a custom built jumping platform covering an area of 91.4   91.4 cm. Athletes placed the PVC pipe on their shoulders similar to a back squat. For SJ, athletes were instructed to squat down to the ready position (90° knee angle measured using a handheld goniometer) and await the verbal command of "3, 2, 1, jump!" before jumping. Maximal effort jumps were preceded by warm-up jumps at 50% and 75% perceived effort. Athletes were given at least 60 s between SJ and CMJ tests. During the CMJ test, athletes were instructed to stand still and await the verbal command of "3, 2, 1, jump!" before performing a CMJ from a self-selected depth. A single warm-up CMJ at 75% perceived effort preceded maximal effort trials.

Jump height and peak power were selected as variables of interest because both exhibit strong relationships to weightlifting ability [7,8]. All vertical jump testing trials were recorded and analyzed using a custom analysis program (LabView 2010, National Instruments Co., Austin, TX, USA). Squat jump height (SJH) and CMJ height (CMJH) were estimated from flight time as previously described [18]. Peak power was determined as the maximal value obtained from the product of the force–time trace and derived velocity–time trace during the concentric phase of the jump. Peak power was allometrically scaled (PPa) to the lifter's BM for both SJ (SJPPa) and CMJ (CMJPPa). The mean of two trials within a 2 cm difference in jump height was used for analysis. Additional trials were performed if the difference in jump height was greater than 2 cm. Test–retest reliability has been recently reported from our laboratory for JH (ICC = 0.93 to 0.99, CV = 2.08 to 7.32%) and PPa (ICC = 0.95 to 0.98, CV = 2.20% to 2.31%) [20,21].

2.5. ISOMETRIC MID-THIGH PULL

The IMTP was performed on force plates (Rice Lake Weighing Systems, Rice Lake, WI, USA; 1000 Hz sampling rate) covering an area of 91.4   91.4 cm inside of a custom designed power rack in which a fixed bar could be adjusted for each subject's appropriate mid-thigh position. Athletes were positioned into their respective power positions, similar to the start of the second pull of a clean with the knee angle set to 125 ± 5° measured with a handheld goniometer. Athletes were positioned with an upright torso and hip angle of approximately 145 ± 5° [1]. Athletes were then secured to the bar in their respective clean grip positions using lifting straps and athletic tape to remove grip strength as a limiting factor. A stable body position with a minimal pre-tension pull was initiated and verified on the force–time curve before receiving further verbal pull commands. Pre-tension was initiated by a verbal command—the tester stated "steady tension on the bar," followed by a countdown "3, 2, 1, pull!" Athletes were instructed to continue to pull until the tester gave a downward hand signal. Each athlete completed warm-up attempts at 50% and 75% perceived effort before performing a maximal effort attempt. For the maximal effort pulls, athletes received loud, verbal encouragement to pull as "fast and hard" as possible. It has been suggested that giving verbal encouragement to achieve a higher IPF for each trial allows variables such as RFD to be measured appropriately [22]. If a countermovement on the force–time curve ≥200 N was observed before the pull or after a continuous pull, the athlete was given another attempt. The test was terminated if a consistent decrease or plateau in IPF was observed. A third trial was also administered if a difference of ≥250 N was observed between the first two trials. Athletes were given 2–3 min of rest between attempts.

Further procedures were in accordance with previous reports from our laboratory [1,15]. The start of each pull was identified by visual inspection [23]. Ground reaction forces were measured only in the vertical direction. IPF and average RFD from 0 to 200 ms (RFD200) were considered for the analysis. The monitoring of IPF and RFD is important in weightlifting given the need to produce high vertical ground reaction forces, particularly during the second pull phase of the clean [23]. IPF has been shown to have strong relationships with maximal strength, RFD200, and weightlifting performance [12,13,14,15]. All IPF values reported were gross values that were not offset by the athlete's BM on the force plate. Thus, IPF was allometrically scaled to each athlete's BM (IPFa) to determine relative IPF values using the equation:

IPF•

BM

2

3

IPF•BM−23

Analog data from the force plate were amplified and conditioned (low-pass at 16 Hz) with a Transducer Techniques amplifier and conditioning module (Temecula, CA, USA). An analog-digital converter (DAQCard-6063E, National Instruments, Austin, TX, USA) was used for collection at 1000 Hz. A custom analysis program (LabView 2010, National Instruments Co., Austin, TX, USA) was used to analyze the mean of two trials at 100% effort within an IPF of 250 N apart. Interclass correlations (ICC) and coefficients of variation (CV) for IPF and RFD have been recently reported from our laboratory (ICC = 1.00, CV = 0.53%; ICC = 0.92, CV = 16.25%) [24].

2.6. WEIGHTLIFTING PERFORMANCE

Competition results for the snatch, clean and jerk, competition total, and ST were used to correlate absolute and scaled competition results to laboratory testing performance. The Sinclair formula is a polynomial equation used to adjust a weightlifter's competition total to allow for comparison between lifters of different body mass; this formula is based on world records set during the previous Olympiad [25,26]. This method adjusts a lifter's total to what it would be if they had a maximized body mass in the highest body weight category, given their current skill level. For the current Olympic cycle, the Sinclair formula is as follows:

Male: ST=Unadjusted Total· 10 AX
2, where X = log 10 (BM·175.508 1)
and A=0.751945030

Male: ST=Unadjusted Total·10AX2, where X=log10 (BM·175.508 1)
and A=0.751945030

Female: ST= Unadjusted Total·10 AX
2, where X = log 10 (BM· 153.655 1)
and A=0.783497476

Female: ST=Unadjusted Total·10AX2, where X=log10 (BM·153.655 1) and A=0.783497476

If a lifter's BM is greater than 175.508 kg (men) or 153.655 kg (women), then the absolute total should not be adjusted (i.e., the Sinclair total is the same as the unadjusted total).

2.7. STATISTICAL ANALYSIS

After the data set was scanned for outliers (cutoff: mean 3 SD), normality was assessed using the Shapiro–Wilks test. Pearson's product moment zero-order correlations were calculated to determine the relationships between variables of the three testing methods (SJ, CMJ, IMTP) with absolute and scaled competition results. Fisher's r-to-z transformation was used to compare correlation coefficients between each testing method and competition results while factoring in the shared variance between the testing variables [27]. A Holm's sequential Bonferroni procedure was used to control Type I error inflation [28]. Correlation coefficients were evaluated using the following scale:

0.0–0.1 trivial, 0.1–0.3 weak, 0.3–0.5 moderate, 0.5–0.7 strong, 0.7–0.9 very strong, 0.9–1 nearly perfect [29].

The alpha criterion for all analyses was set at p 0.05. SPSS software version 23 (IBM Co., Armonk, NY, USA) and Microsoft Excel (Microsoft Corporation, Redmond, WA, USA) were used to perform all statistical analyses.

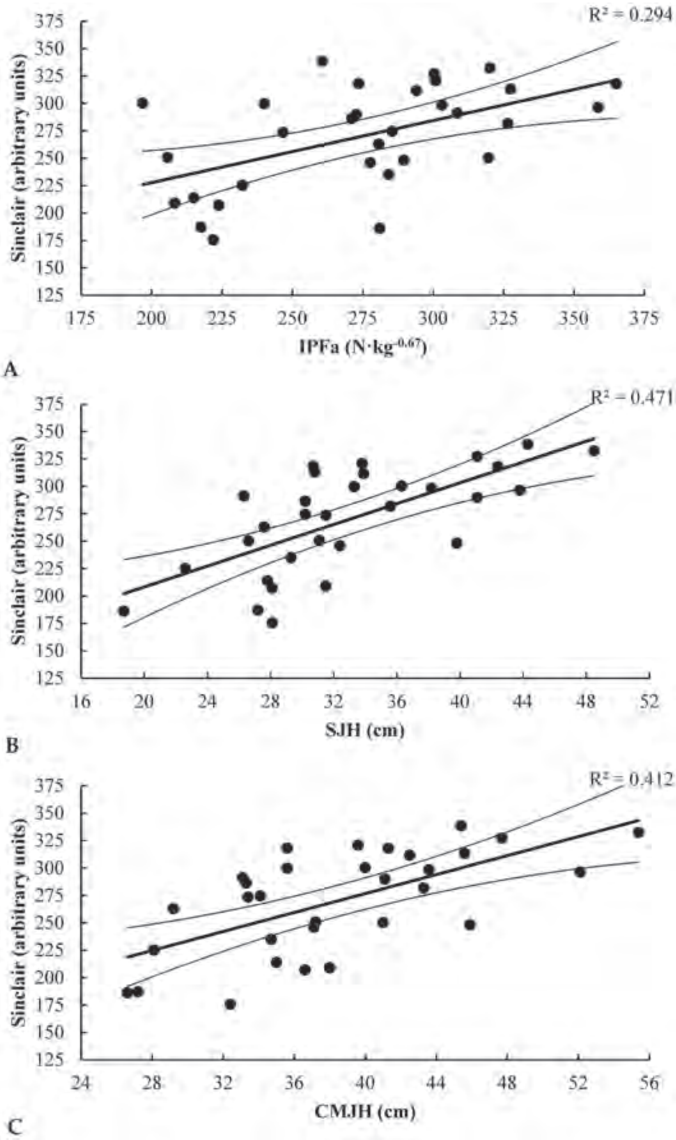


FIGURE NO. 1

THIS FIGURE SHOWS THE RELATIONSHIPS BETWEEN EACH TESTING VARIABLE AND THE SINCLAIR TOTAL: (A) RELATIONSHIP BETWEEN IPFA AND SINCLAIR TOTAL FOR MALES; (B) RELATIONSHIP BETWEEN SJH AND SINCLAIR TOTAL FOR MALES; (C) RELATIONSHIP BETWEEN CMJH AND SINCLAIR TOTAL FOR MALES. IPFA: ISOMETRIC PEAK FORCE, ALLOMETRICALLY SCALED; SJH: SQUAT JUMP HEIGHT; CMJH: COUNTERMOVEMENT JUMP HEIGHT.

3. RESULTS

3.1. MALE WEIGHTLIFTERS

A moderate relationship was found between IPF and the competition total ($r = 0.495$, $p < 0.001$), while strong relationships were found between IPFa and both the competition total ($r = 0.571$, $p < 0.001$) and ST ($r = 0.542$, $p < 0.001$). Squat jump height displayed strong relationships with both the competition total ($r = 0.607$, $p < 0.001$) and ST ($r = 0.686$, $p < 0.001$), and SJPPa showed moderate relationships with the competition total ($r = 0.388$, $p = 0.031$) and ST ($r = 0.394$, $p = 0.028$). Countermovement jump height displayed strong relationships with both the competition total ($r = 0.541$, $p < 0.001$) and ST ($r = 0.642$, $p < 0.001$). Within-sex comparisons for the male weightlifters showed the following relationships:

ST–IPFa vs. ST–SJH ($z = -0.873$, $p = 0.191$), ST–IPFa vs. ST–CMJH ($z = -0.578$, $p = 0.281$), and ST–CMJH vs. ST–SJH ($z = 0.295$, $p = 0.384$)

The observed statistical power ranged from 0.05 (RFD–ST) to 0.99 (SJH–Sinclair) for all male analyses.

3.2. FEMALE WEIGHTLIFTERS

In female weightlifters, a moderate relationship was observed between SJH and ST (r = 0.487, p = 0.025), but this was not statistically significant after correcting for multiple comparisons (Figure 2). Within-sex comparisons for the female weightlifters showed the following relationships:

ST–IPFa vs. ST–SJH (z = −1.728, p = 0.042), ST–IPFa vs. ST–CMJH (z = 1.45, p = 0.074), and ST–CMJH vs. ST–SJH (z = −0.279, p = 0.39)

The observed statistical power ranged from 0.04 (IPF-ST) to 0.69 (SJH-Sinclair) for all female analyses.

Figure 2. Bivariate correlations.

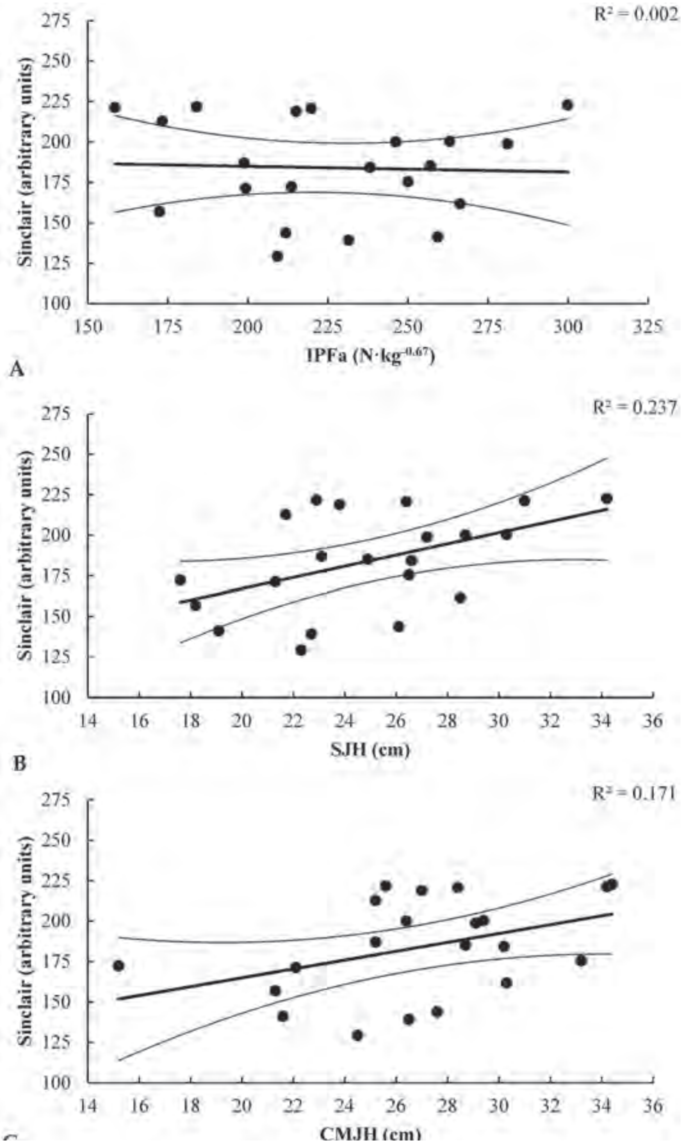


FIGURE NO. 2

THIS FIGURE SHOWS THE RELATIONSHIPS BETWEEN EACH TESTING VARIABLE AND SINCLAIR TOTAL: (A) RELATIONSHIP BETWEEN IPFA AND SINCLAIR TOTAL FOR FEMALES; (B) RELATIONSHIP BETWEEN SJH AND SINCLAIR TOTAL FOR FEMALES; (C) RELATIONSHIP BETWEEN CMJH AND SINCLAIR TOTAL FOR FEMALES. IPFA: ISOMETRIC PEAK FORCE, ALLOMETRICALLY SCALED; SJH: SQUAT JUMP HEIGHT; CMJH: COUNTERMOVEMENT JUMP HEIGHT.

4. DISCUSSION

The purpose of the present study was to determine the relationships between vertical jump, IMTP, and weightlifting performance, and to compare vertical jumps with IMTP as monitoring tests of weightlifting performance in a large cohort of male and female weightlifters competing at various levels.

The results of this study reject our original hypothesis that strong relationships would be observed between vertical jumps, IMTP, and weightlifting performance in male and female weightlifters. Only male weightlifters showed strong relationships between all performance tests and weightlifting performance (Figure 1). In contrast, females only showed a moderate relationship between jump height and weightlifting performance (Figure 2).

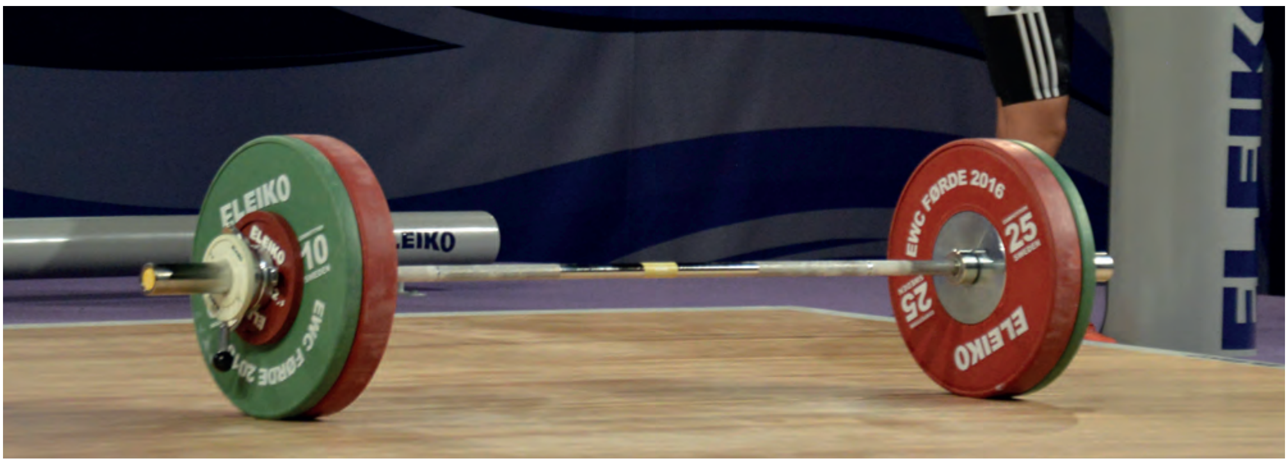
The results of the current analysis disagree with those of Beckham et al. [15] regarding the strength of the relationships between both IPF and IPFa to absolute (r = 0.838, p 0.05; r = 0.610, p ≤ 0.05) and scaled (r = 0.775, p ≤ 0.05; r = 0.737, p ≤ 0.05) weightlifting performances. However, the authors do agree that significant positive relationships exist. The differences between Beckham and colleagues' findings and the current study may be attributed to sample size (10 males and 2 females vs. 31 males and 21 females, respectively), competition attempt selection, or athlete characteristics such as anthropometrics and weightlifting ability. However, the male athletes' ST and IPFa were

comparable between studies (258 45, 288 ± 49 N•kg 0.67 vs. 270 47, 274 ± 45 N•kg 0.67, respectively). Also, Beckham and colleagues' analysis combined the results from the males and females together, whereas the current analyses separated them due to differences in the relationship between laboratory performance measures and weightlifting performance. The non-significant and trivial to weak relationships between competition performance and both IPF and IPFa in females may indicate that these athletes were limited by their weightlifting technique rather than strength influencing successfully completed lifts.

The current sample of female weightlifters is ranked below the female weightlifters used in similar studies that observed the same performance measurements [12,13,14]. In these studies [12,13,14], all of the female athletes (n = 7, n = 6, n = 6, respectively) were USA Weightlifting resident athletes who would be classified as Master of Sport International Class (i.e., the highest achievable classification). The female athletes used in these studies [12,13,14] were significantly stronger than the current sample with respect to average snatch (91 ± 7.7 kg), clean and jerk (112 ± 11.7 kg), and competition total (203 18.7 kg). The group of female weightlifters in these studies outperformed the current sample on vertical jump SJH (29.0 ± 5.0 cm), CMJH (31.0 ± 4.0 cm), and RFD during IMTP (13,997.2 1879.3 N•s 1). However, although comparable, this group underperformed on IMTP IPF (3510.0 ± 587.0 N) and IPFa (202.5 ± 35.5 N•kg 0.67). Thus, the current investigation agrees with Stone et al. [12] that correlations between measures of maximum strength and weightlifting performance are generally lower for women than men, yet weak and trivial correlations between IMTP and weightlifting performance for females were not expected. Therefore, women's performance in weightlifting may be relatively more dependent on other factors such as mobility, technique, or speed under the bar rather than maximum strength (i.e., IPF, IPFa). With respect to the sample used in this investigation, although the females demonstrated greater strength capabilities on the IMTP compared to similar studies with more competitive female weightlifters, the average competition performance and ST was not sufficient to show stronger relationships. Therefore, the authors suggest that athletes with less competition experience, particularly female athletes, should primarily focus on weightlifting technique before shifting the training emphasis towards maximum strength. Stone et al. [12] state that weightlifting is not solely dependent on maximal strength, but is highly influenced by technical factors, possibly explaining the differences in relationships observed between previous findings and the current investigation.

In a recent review by Maffiuletti et al. [23] the authors stated that RFD seems to be strongly related to performances of sport-specific tasks such as ballistic actions for strength athletes, and is a sensitive concurrent indicator of neuromuscular function for accumulated fatigue. Further, isometric RFD, particularly at later time points (i.e., 200 and 250 ms), has been shown to be closely related to maximal isometric force and weightlifting performance [13,14,30,31]. In the current investigation, RFD showed trivial and weak relationships in males and females. One explanation for these findings may be that some or all of the athletes had not fully recovered during the active recovery period following the competition, and thus carried neuromuscular fatigue that impacted IMTP performance. There is evidence that suggests acute and chronic fatigue leads to a reduction in RFD, and peak force capabilities in elite female weightlifters [14] which may explain our findings. However, previous analyses from our laboratory have shown very strong correlations (r ≥ 0.94) between isometric data collected pre and post weightlifting competition as much as four months apart [15]. Nonetheless, the lack of strong or significant relationships between RFD and weightlifting performance is surprising and may point to unmeasured confounding factors within the current investigation.

Both SJ and CMJ performance correlated with weightlifting performance in males, with SJH displaying the strongest correlations to both competition total and ST. Squat jumps are unique in that they require both explosive strength ability and a rapid take-off velocity, and exhibit stronger correlations with maximal strength (e.g., 1-RM back squat, IMTP peak force) than CMJs [14,30,32]. Squat jump performance is also unique to weightlifters because it is considered to be biomechanically similar to the starting positions of the snatch and clean and jerk [10]. The act of holding the start position is thought to remove the contribution of series elastic components in the hip, knee, and ankle extensors so that the jumper must rely on concentric muscle action instead of the stretch-shortening cycle to generate high take-off velocities [33,34]. During what is known as "the double-knee bend", weightlifters preload the leg extensor musculature during the transition into the second pull (i.e., the "power position"–the same position used in IMTP tests) [32]. Despite this potential invocation of the stretch-shortening cycle, a majority of the pull phase in both the snatch and clean involve concentric-only muscle actions. Even the double-knee bend, or shifting of the knees forward by extending the hips, may be a pause in knee extension rather than active knee flexion, resulting from a repositioning of the extensor muscles and spine to more optimally accelerate the barbell [35,36]. It may be that the strong correlations that SJH and SJPPa showed with the competition total and ST in males were due to these similarities in muscle action. The absence of these relationships in females may further highlight the sex-based differences in weightlifting technique in the current sample. An athlete with less experience and lower skill level may lack the ability to fully express their physical abilities in a competition setting. Various physiological, biochemical, psychological, and neuromuscular measures have been used to monitor weightlifters [1]. While this study only focu-



sed on neuromuscular measures related to weightlifting performance, it is clear that athlete monitoring requires a broader 'systems approach'. Training decisions should not be based on a single measurement. Nonetheless, a balance is needed to avoid over- or under-testing athletes. Thus, this study adds insight into weightlifting monitoring in a large sample of weightlifters across various skill levels. A few limitations, albeit difficult in practice, include the timing of testing relative to competition, the use of weightlifting competition results, and inclusion of only neuromuscular laboratory tests. However, these limitations are overcome by the large, heterogeneous sample of weightlifters, and the use of robust measurements of maximal strength and jumping performance.

5. CONCLUSIONS

Based on the results of the current analysis, SJH was the strongest correlate of weightlifting performance in the cohort's most recent training and competition cycle. However, the relationship was weaker among female athletes which is likely due to discrepancies between strength levels and actual competition performance. Caution should be applied as longitudinal data is needed to confirm that SJ variables are sensitive to weightlifters' training responses. Nonetheless, SJs can be used as a reliable measure to monitor weightlifting performance across a wide-range of weightlifting abilities.

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AUTHOR CONTRIBUTIONS

S.K.T. and C.D.B. conceived the experiment and performed the retrospective analysis of the data. S.K.T., J.R.G., G.K.B. and C.D.B. contributed to the writing and revision of the paper. Conflicts of Interest: The authors declare no conflict of interest.

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SCALING OF BODY MASS IN WEIGHTLIFTING:

CONSEQUENCES FOR THE WORLD'S STRONGEST WEIGHTLIFTERS

BY ANDREW CHARNIGA

"…excess bodyweight first creates additional loading on the sportsman's muscles because the weightlifter has to lift this excess weight during the execution of the weightlifting exercises; second, the sportsman's speed deteriorates."

Abramovsky, 2002

Special conditions exists for improving results in the unlimited weight classes in weightlifting. An unlimited weight division permits a lifter to increase his/her weight in the snatch and the clean and jerk by means of increasing body mass with no worries at the weigh – in. However, this can be accomplished without necessarily improving technical skills; or, even retaining motor skills achieved at a lower body weight. In most cases athletes in the unlimited classes raise more weight by using the larger body mass to overcome a proportionally smaller mass of barbell. However, there are a number downsides to this mass over mass equation.

Meranzov (1985), Spasov, Sinclair and others cite a bodyweight of 140 kg as the point of diminishing returns for a weightlifter of the modern era. However, this figure pre – dates the appearance of the female weightlifter in international weightlifting. A casual observation of the state of women weightlifters at the present time indicates a point of diminishing returns as far as body weight is concerned is much lighter than 140 kg.

Female weightlifters have smaller bones, comparatively less muscle mass and proportionally greater fat mass than their male counterparts. Consequently, with the rise in bodyweight in excess of the now 90 kg border, females will tend to add more fat mass relative to the increase in muscle mass. Therefore, diminished technical efficiency with the rise in body mass ostensibly is a larger problem for the +90 kg class athlete. The +90 kg athletes will tend to raise proportionately more fat mass when lifting the barbell. Which of course, exacerbates the two downsides pointed out by Abramovsky (2002): extra effort is expended raising excess, even non – functional body mass; speed of movement deteriorates.

FIGURE NO. 1
THE WORLD'S STRONGEST MAN REACTS TO MISSING A WORLD RECORD 221 KG SNATCH.

CHARNIGA PHOTO.

Dinasaurs of weightlifting's past such as world champions Hepburn and Anderson raised weights in their day which have been exceeded by females of today, weighing as much as 20 kg less. Schemansky and Davis (both USA) at around 102.5 kg bodyweight; made those behemoths obsolete already in the 1950s; but, with the appearance of Zhabotinsky (USSR) and Alexeyev (USSR) the huge unlimited athlete re- emerged; with one major distinction. Unlike the 140 – 160 kg monoliths of the past these 160 kg Soviet lifters were very athletic. Yet, with their appearance on the international scene Kurlovitch and Pisarennko, at around 120 kg bodyweight, represented a new wave of the world's strongest man. Considerably leaner, with less muscle mass, they lifted the biggest weights; with strength accentuated by speed of movement and flexibility.

That being said, we are back to an age ruled by 160 – 170 kg giants. And, with the return of the giants lessons of the past have been forgotten; the problems connected with failure to scale body mass in conformity the dynamics and kinematics of the competition exercises are being repeated.

Two of the not so obvious yet critical problems connected with failure to scale body mass: difficulties with jerking the barbell (especially the third attempt in competition) and fixing the barbell in the snatch.

THE JERK FROM THE CHEST

Research has shown the lightest lifters are more skillful in the jerk from the chest. Lifters in the light weight classes lift 250 – 305% of bodyweight. This huge disparity between the athlete's mass and the weight lifted necessitates a combination of power and highly refined skill to raise the barbell and still balan-

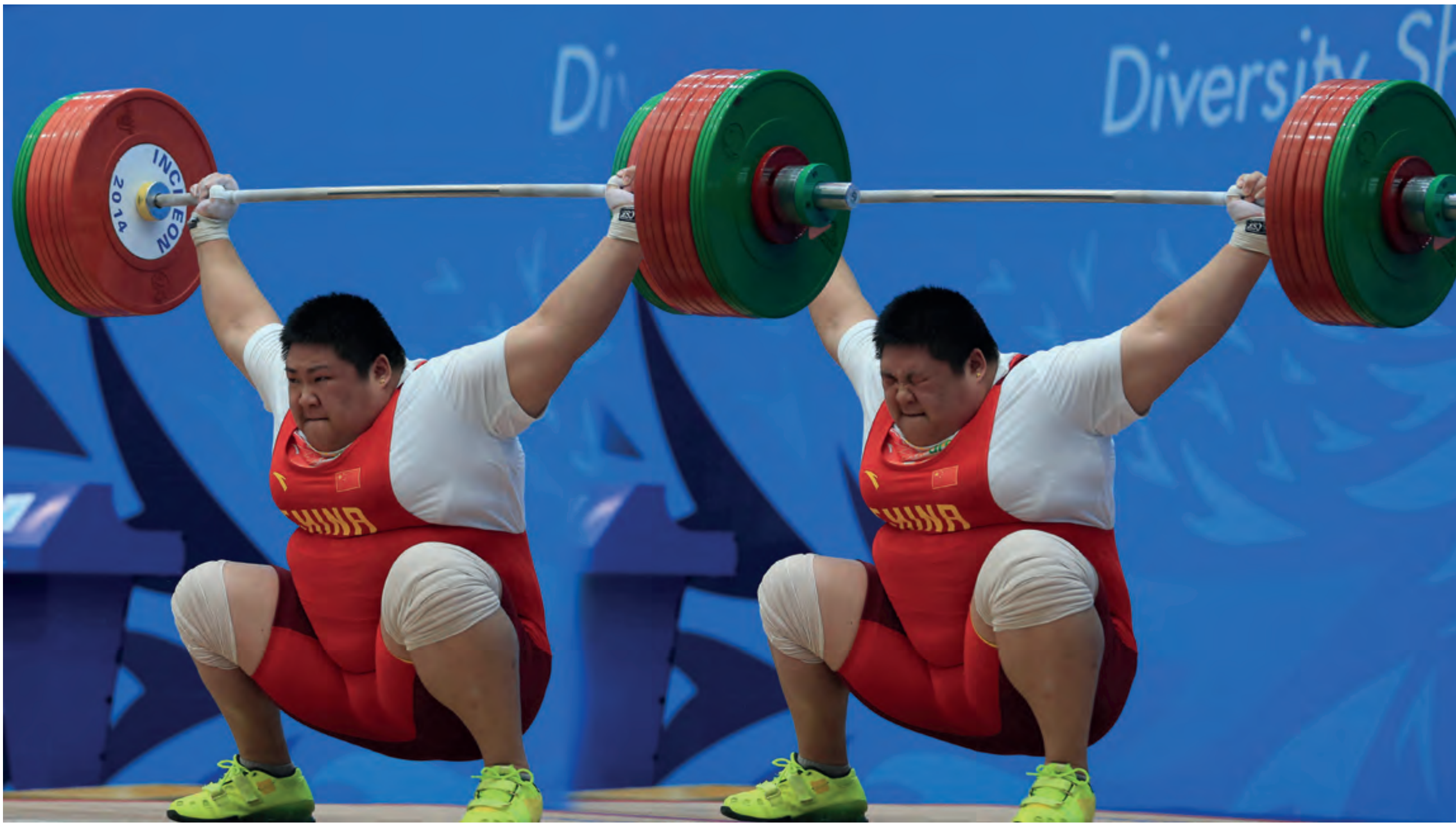

FIGURE NO. 2

OLYMPIC CHAMPION IS UNABLE TO FIX THE BARBELL IN A STABLE SQUAT BECAUSE THE GIRTH OF THE ATHLETES BELLY AND THIGHS COMBINE TO PREVENT HER FROM EFFECTIVELY AMORTIZING THE DOWNWARD PATH OF THE BARBELL AND COUNTERBALANCING THE WEIGHT IN THE SQUAT POSITION BY TILTING THE TRUNK AND SHINS FORWARD. NOTE: SHINS SHIFT FROM A SLIGHT FORWARD LEAN TO VERTICAL AS THE ATHLETE LOSES BALANCE.

CHARNIGA PHOTO.

ce the athlete – barbell – system. The toppling over effect of such huge weights exerts a forward pull on the athlete – barbell unit; making balance the critical factor to lift such huge weights successfully. Think of gravity pulling in two planes simultaneously: vertical and horizontal.

On the other hand the record weights of the top super-heavyweights range from only 164% of bodyweight for the 2016 Olympic champion to about 189% for some of the lighter supers; and, 147.5% for the 2016 female Olympic champion to only 112% of bodyweight for lower level; yet proportionally much heavier females.

The bigger weights lifted by the +105 kg and the +90 kg lifters obscures the fact their technical skills don't necessarily improve or even remain the same as their bodyweight rises. This is quite obvious from the troubles experienced by Iranian +105 kg, Salimikordasiabi. His increased bodyweight over time has accompanied by a decrease in technical proficiency. He is able to lift a big weight (250 – 255 kg) in the jerk; but, repeatedly experiences difficulties raising it within the rules.

Assistance exercises such as the push press, push jerks, bench presses and others over time can exacerbate the problem of jerking the heaviest weights the +105 kg lifter can clean. With body mass surpassing 165 kg for males and somewhat less for female +90 kg lifters there is a definite tendency to 'muscle' the weight with the arms at the expense of accentuating the legs; especially, the action of forcefully scissoring the feet into the split position.

There are a number of causes for a deterioration of technical efficiency.

The weight of the barbell is proportionally lighter relative to the lifter's body mass; which in turn, means the toppling over effect is less. Consequently, an accentuated wide scissoring of the feet is not near as critical as it for someone lifting say 250% of bodyweight and more.

The +105 and +90 kg lifter has to expend more energy moving his/her mass from the starting position into the split, i.e., speed of movement deteriorates.

The lifter's arms and shoulder muscles are usually bigger and stronger; so in lieu of the extra energy to move the whole body; lifters will tend to accentuate the role of the muscles of the arms and shoulders. As a result, the technique of jerking the barbell can deteriorate into a shuffling of the feet and a push – pressing of the weight up.

An element of effective technique in the jerk often overlooked: the hands should push the body away from the barbell (Luchkin, 1945; Zhekov, 1976); not push up, as in pressing. This important element of good technique is critical for someone endeavoring to raise upwards of 300% of bodyweight; but, much less a necessity for someone lifting 124 -164%. A good example of this is the 170+ kg athlete from Iran pressing the weight up instead of pushing his body down; and,

in the process his lifts are turned down.
The +105 and +90 kg athletes can successfully jerk a heavy weight with a forward barbell trajectory slightly greater than lighter lifters because the toppling over influence is considerably less with 124 – 164% of bodyweight than it is with, say 250% weights. This in turn creates the illusion their technique is okay because they make lifts someone endeavoring to raise 200 – 250% cannot; with such a mechanical error.

FIXING THE BARBELL OVERHEAD

Fixing the barbell on straight arms in the jerk is made more difficult than it should be by pressing up on the barbell. Likewise fixing the barbell at arms length in the snatch is a complex motor task; which is made more difficult for the biggest athletes because of impediments created by their girth, exercise selection and slower speed of movement.

Figure No. 3
+105 lifter successfully muscles 252 kg to arms length; but the lift is not allowed due to press out.

Charniga photo.

Figure No. 4

Three elite lifters: two females and the world's strongest man illustrate the complex mechanics of fixing a maximum weight at arms length in the squat. In all three examples the the barbell is fixed with varying forward tilting of the shins. The lifter on the right has a significant leaning of the shins with a minimal trunk tilt. The +105 lifter has the least lean of shins and trunk forward (center figure). The lifter on the far right has a moderate leaning of shins combined with a significant tilting of trunk forward. At any rate, the lifters have counterbalanced the athlete – barbell unit with varying portions of the body disposed in front of and behind the barbell.
Charniga photos .

The combined girth of the belly and thighs of the biggest athletes conspire to force the athlete fix the weight higher i.e., creating a less stable center of mass of athlete – barbell unit. Compare the height of hip joint in the three photos in the figure. However, the biggest problem for the +105 and +90 kg lifters occurs when the belly meets the thigh as the lifter turns the weight over to fix it at arms length. The inability to sink lower as the belly meets thighs can push the shins towards vertical and cause the athlete to drop it. See figure 2.

HEIGHT OF LIFTING IN THE PULL

The height of lifting the barbell in the pull required to fix a weight on the chest in the clean and overhead in the snatch is a simplest and probably the best indicator of the athlete's technical proficiency. The higher the barbell has to raised the more energy expended overcoming gravity, the less efficient the technique. Typically the bigger guys/gals have to lift the barbell to a greater height relative to their stature because with the rise in body weight, the increased girth of the waist and thighs combine to limit the depth of squatting under the weight. Lifters clean the barbell with relatively vertical disposition of the trunk in the squat position. Consequently, as a weightlifter's body mass increases, fixing the weight on the chest is not as big a problem for these athletes. However, the increasing girth of the waist and the thighs which accompany the rise mass can eventually make fixing the barbell on the chest more difficult either because the weight has to be lifted higher or the lifter has to struggle to fix the weight on the chest as the belly and thighs collide in the squat.

"Muscular tension in the working muscle groups during the performance of the explosion usually reaches optimum {with missed attempts at limit weights the force applied to the barbell usually exceeds the same force of successful attempts}"

Druzhinin, 1974

A not so easy situation for the coach to determine with any, let alone the biggest lifters, is excess effort applied to the barbell to compensate for the excessive girth and slower speed of movement. As the quotation from Druzhinin above indicates, in many cases more force can be applied in missed attempts than sufficed for successful. In our case the bigger athletes will try to pull longer and harder than necessary to lift a maximum weight; partly in order to compensate for the inability to drop into a low squat and balance the weight with some forward lean of the shins/trunk in the snatch.

HEIGHT OF FIXATION OF THE BARBELL IN THE SNATCH

The amortization of the barbell is a critical element of technique often overlooked, or simply just not understood, especially for the snatch. The action of amortizing the weight during the descent into the squat creates a re – ward 'hook' in the barbell's trajectory. The distance the barbell descends from the high point of the pull to the lowest height in the squat is the amortization. A optimal hook facilitates fixing the barbell over head. It allows the lifter to fix the weight and position the body in the low squat. Part of the rearward portion of this hook is created as the athlete sinks into the low squat position. Inability to drop low enough to amortize the barbell effects this rearward hook and of course will leave an otherwise accessible weight slightly forward.

BALANCE

Balance is another critical skill which usually deteriorates with a failure to scale body mass commensurate with the dynamics of the competition exercises. Balance is a problem for the biggest lifters because they typically are unable to squat to a low position under the barbell.

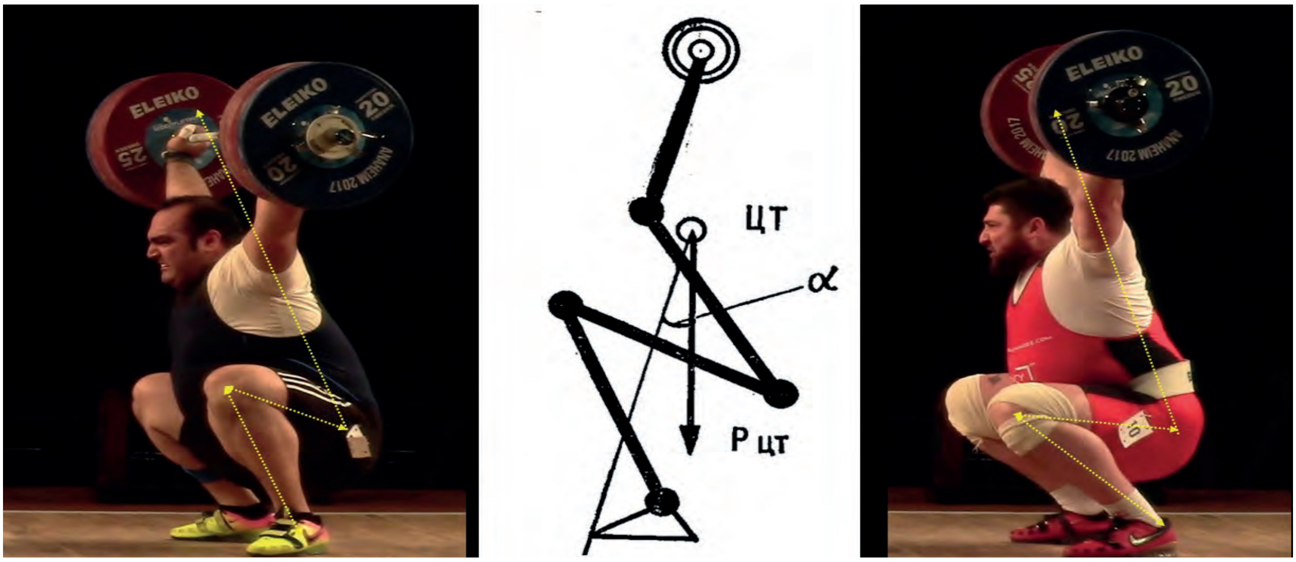

FIGURE NO. 5

The lifter in the photo on the left is in the process of losing a 216 kg snatch despite having fixed the weight overhead on straight arms. He is unable to either lean forward or tilt shins forward sufficiently (as belly is up against thighs) to effectively counterbalance the system athlete barbell. The lifter with 215 kg on the right is able to counterbalance the athlete barbell system with shins tilted forward and slight leaning of trunk; but, likewise with no space between belly and thighs. The figure in the middle from Zhekov's Biomechanics of the Weightlifting Exercises, depicts the angle of dynamic balance in the low squat. Note body segments lie in front and behind the vertical line of the bar. Such a disposition of body relative to barbell becomes increasing difficult with the rise in body mass of the +105 and +90 kg lifters.

This means the barbell has to be fixed at the chest or overhead higher from the platform, i.e., the center of mass of the system is proportionally higher relative to the athlete's height. A simple indicator of balance especially in the snatch is depicted in the photos in figure 4 & 5. A disposition of body and barbell sufficient to achieve dynamic balance in the squat position of the snatch is created by having some part of the body in front and behind the vertical projection of the barbell. Consequently, the larger the body mass the higher the athlete sits in the squat; the lesser the possibility to counterbalance the athlete – barbell system: to have shins tilting forward with some leaning of trunk forward, with hips slightly behind the vertical projection of the barbell (figures 4 & 5).

SELECTION AND EXCESSIVE USE OF EXERCISES OUT OF SYNC IN TIME AND SPACE

Athletes frequently mimic the techniques, training methods, exercises and so forth of the best in sport. This is certainly not a new phenomena. However, everyone is different and just because a champion does some exercise doesn't necessarily mean it is one of the secrets to his/her success. Coaches and athletes often don't take the time to analyze the long term effects of assistance exercises.

In light of what has been presented about problems of jerking the barbell, push press, push jerks and other similar exercises where the habit is ingrained to press upward; such assistance exercises for the jerk are not advisable; especially for the biggest athletes.

One exercise in particular which is popular with many lifters is the so – called muscle snatch. This exercise stands out as being out of sync in time space with the skill to lift maximum weights. The barbell is lifted from the floor or from the hang to arms length without squatting under it, i.e., using only arm and shoulder muscles to raise it as it passes the waist.

Even though this movement seems entirely consistent with the muscle actions of the snatch, the motor pattern is quite different.

First, the lifter is practicing lifting the barbell higher than is necessary to raise a maximum weight, i.e., out of sync in space. Second, the lifter spends more time lifting the weight upward, i.e., out of sync in time. Third, the motor skill to fix the the weight overhead is radically different than the actual action of fixing the weight from a rapid drop into the squat position. Fourth, variations of performing the exercise range from a a high pull and passive turnover of the barbell to a high pull and a strenuous press up, as depicted in figure 6.

The high pull and press up version is without a doubt the worst version for transfer of habits to the skill required to lift maximum weights.

This exercise is particularly popular with the people who should do it the least, the +105 lifters. The skills inherent to lifting a maximum weight in the snatch can and usually do deteriorate as body mass approaches the point of diminishing returns. The specificity of the

"Exercises directed at the formation (transformation) of competitive actions "in parts", must not essentially differ in their main structural form from the reproduced "parts" of the competitive exercise (analysis must confirm the structure is correct). If this condition is not met, the preparatory exercise will be formed not as a skill of the competition exercise but as some other skill. This may cause interference (negative transfer) of skills.

L. P. Matveyv, 1977

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skill connected with lifting a maximum weight in the snatch involves actively turning the bar over during the descent (as lower extremities flex) into the squat while instantaneously switching from pulling the body down (which is not done in the muscle snatch) to pushing the barbell up and back to fix it and counterbalance the system.

GENERAL DETERIORATION OF MOTOR SKILLS

As body mass increases past some reasonable point of diminishing returns there is a general deterioration of the motor skills. A shift away from accentuating moving the body to using muscle and body mass to raise the barbell; primarily due to the aforementioned fact that it takes extra energy to move unnecessary body mass.

CONCLUSIONS

There is a positive outcome to be had from increasing body mass. The athlete lifts bigger weights; even though the bigger weights lifted are not the same percentage of his/her body mass. The downside is the

FIGURE NO. 6

LIFTER IS PERFORMING THE 'HIGH PULL AND MUSCLE UP' VERSION OF THE MUSCLE SNATCH WHICH BEARS NO RESEMBLANCE TO THE SKILL OF LIFTING MAXIMUM WEIGHTS IN THE SNATCH.

bigger weights, as a percentage of the lifter's bodyweight, a simple indicator of mechanical efficiency, invariably declines.

This simple fact is often ignored and is all the more apparent with the female weightlifter. The recent introduction of the 90 kg class is a good example of an error in judgement. Generally the 90 kg results have been lower than the winning results in the 75 kg and even lighter classes. For instance, the winning result of the 90 kg class at the 2018 Chinese national championships was 253 kg; whereas the winning result at 75 kg was 273 kg. Even the winning result of 264 kg for the 69 kg was 11 kg greater at a bodyweight of 21 kg less.

For all of the reasons enumerated above, the additional mass added to a generally smaller frame does not translate into improved or a preservation of the specificity of the motor skills to raise maximum weights. It would be a good idea to have a weight limit for the female unlimited class of say 130 kg. For instance, the winning result of the 2017 Senior World Championships was a -7.69 kg less than (snatch – bodyweight + jerk – bodyweight) the bodyweight of the gold medalist.

A primary consideration for the biggest athletes is to endeavor to achieve some mass which is reasonably commensurate with the dynamics of the competition exercises such that unnecessary fat and girth do not impede the athlete's ability to move in a manner consistent with the best technique for lifting maximum weights.

The coordination structure of assistance exercises selected for all lifters, especially the biggest athletes, need to conform as closely as possible with the skills requisite for lifting maximum weights.

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The official journal of the European Weightlifting Federation

THE ELEIKO STORY

IT ALL BEGAN WITH A SWEDISH WAFFLE IRON

Sandor Sakarny,
Eleiko craftsman since 1992.

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Tyra Johansson,
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EDITORIAL GUIDELINES

EDITORIAL GUIDELINES FOR AUTHORS OF ORIGINAL RESEARCH WORK TO BE PUBLISHED STRENGTH & CONDITIONING. THE SCIENCE OF HUMAN MOVEMENT (S&C).

EWF Scientific Magazine (hereafter *SM*) is a scientific journal published by the European Weightlifting Federation (EWF). *SM* publishes surveys and research reports, systematic reviews, reviews, collections of studies, research notes and technical and methodological reports - both original and those drawn from the most Authorized international scientific literature available (with particular but not exclusive reference to the three magazines of the Strength and Conditioning Association of the United States of America: *the Journal of Strength and Conditioning Research*, *Strength and Conditioning Journal* and *NSCA's performance training journal*), which contribute to promoting knowledge on physical training as a whole and on strength training in sport and physical activity in particular. All original typescripts, accepted for publication, must present either concrete and practical applications for the professional who works in the strength training sector, or provide the basis for further applied research in the specific field. The original typescripts are subjected to "double blind" *peer-reviews* by at least two reviewers who are experts in that particular field. Editorial decisions are taken based on the quality of the work presented, the clarity, the style and the importance of the presentation regarding the aims and objectives of *SM*. Suggestions for the drafting of a paper to be published on *SM* can be found at *http://www.nsca-li- ft.org/publications/JSCRtips.shtml.* Authors are invited to carefully read this interesting document, which is very useful for the preparation of any manuscript to be published.

EDITORIAL MISSION STATEMENT

The editorial mission of *EWF Scientific Magazine* (*SM*) is to work to advance knowledge of the movement and training of mankind, on the assumption that the first is always, and in any case, the expression of muscle strength and that the second constitutes a lifestyle and ethics entrusted to skilfully and thoroughly trained professionals with vast knowledge of the facts, as well as specific competence. Since its first appearance, *SM* has had the ambitious goal of bridging the gaps and misunderstandings between the scientific laboratory and those working in the field, enhancing both the practical experience of the coaches and the results of research, especially applied research. For this reason, it makes - as an editorial rule - constant reference to the practice and the inclusion of recommendations for the implementation of research results in the practice of movement and sport.

The process of improving the overall psycho-physical condition through the implementation of appropriate exercise programmes covers a wide range of people: from children to senior citizens, through all ages, from novices to professional athletes, at all possible levels. For the professional it is important to have an in-depth knowledge of the process of training and to realise how it can be supported by other practices and other areas of knowledge, such as nutrition, rehabilitation and re-education, psychology, technology, special exercise techniques and biomechanics.

Original research

SM publishes studies and research covering both the effects of exercise programmes on performance and on the human body as well as the underlying biological basis. It includes research stemming from the many disciplines whose aim is to increase knowledge about movement in general and sport in particular, their demands, their profiles, workout and exercise, such as biomechanics, exercise physiology, motor learning, nutrition, psychology, rehabilitation and re-education.

One of the primary goals of *SM* is to provide a scientific basis for qualified and updated programmes of physical training and sports training.

Type of articles and their total length

Due to space limitations, *SM* normally publishes articles no longer than ± pages, including bibliography, figures and images (approximately 4 pages of text with line spacing 1 is equivalent to 14,000 characters, including spaces, + 1 page of bibliography + one page of images and figures and graphs). Works of greater length can naturally be accepted for publication, but may be divided into parts or, with particular reference to the bibliography may be suitably posted on the website www.calzetti-mariucci.it .

SM publishes studies and collections of studies and research, systematic reviews, reviews, methodological reports, technical reports and research notes that are associated with and related to the mission of the magazine. A collection of studies is a group of articles by different Authors that address an issue from various perspectives. The reviews should provide a brief critical review of the literature and integrate the results of previous research to inform the reader about the basic aspects and applications of the subject. As noted above, *SM* is mainly concerned with the practical aspects of the literature reviewed and published.

Furthermore, the Author or Authors of the texts submitted for publication must have experience and knowledge in the given area enabling them to declare themselves experts in the field and to ensure credibility to their findings and their recommendations. *SM* strongly recommends the presentation of material that illustrate methodologies to advance the studies on muscle strength and overall training of the same.

GUIDELINES FOR THE PRESENTATION OF ORIGINAL RESEARCH WORK TO BE PUBLISHED

1. A portion of the texts published by *SM*, as a specific editorial choice, are versions in Italian of highly accredited work already published elsewhere, carefully selected among the many papers available in literature. It is also an editorial policy to include research from young up and coming Authors or those in training. Articles may be submitted by e-mail, in the form of files in Microsoft Word format (.doc), to *dir@calzetti-mariucci.it*, following the instructions below. Authors are required to attach the declaration of assignment of copyright for paper and digital publication, which may be downloaded from www.calzetti-mariucci.it.

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5. The material submitted for publication must be accompanied by a brief resume of the Author or Authors.

6. *SM* adopts standards for the protection of living beings, with regard to testing on animals and humans. In this regard, the Authors of the work submitted for publication must have received appropriate approval from their institutional control bodies or if necessary, must demonstrate to have obtained the appropriate consent under the applicable laws. All submissions must include a statement to that effect, in the Methods section of the document presented. Failure to do so will result in the paper not being considered for publication.

7. All texts should be double-spaced, and an extra space between paragraphs. The paper must include margins of at least 2.5 cm and include the page numbers in the upper right corner beside the current title. Authors should use terminology that is based on the International System of Units (SI).

8. The Authors of the texts are invited to use non-sexist language and to show that they are sensitive to the appropriate semantic description of people with chronic illness and disability (as pointed out - for example - in an editorial of Medicine & Science in Sports & Exercise®, 23 (11), 1991). As a general rule, only abbreviations and codified symbols should be used. If unusual abbreviations are used, they must be explained from their first appearance in the text. The names of trademarks must be written with a capital letter and their spelling is to be carefully checked. The names of chemical compounds and generic names must precede the trade name or abbreviation of a drug the first time that it is used in the text.

PREPARATION OF MANUSCRIPTS

1. Title page

The title page should include the title of the paper, the current title in short, the laboratory or laboratories where the research was conducted, the full name of the Author or Authors, the department, the institution, full postal address of the corresponding Author, phone number, fax number and email address; furthermore, a declaration of any funding received for the work carried out must be included.

Title page without the name of the Authors

A second page should be enclosed containing only the title of the paper. This page will be used to send the paper to the Reviewers for the double-blind review process.

3. Summary and Keywords

A separate sheet must contain a summary of the paper in not more than 250 words, followed by a minimum of 3 to a maximum of ± keywords, not used in the title. The summary must be structured in sentences (not titles) related to the purpose of the study, methods, results, conclusions and practical applications arising from the work presented.

4. Text

The text must be composed, as a rule, of the following sections with titles in uppercase and in the following order:

A. Introduction. This section is a careful development of the hypotheses of the study that led to the implementation of the survey. It is advisable not to use subtitles in this section and try to limit it to 4-6 paragraphs, written in a concise manner.

B. Methods. The following subtitles are required in the Methods sections in the following order: "Experimental approach to the problem," where the Author or Authors of the study show that the approach can prove the hypotheses developed in the introduction, and can offer some basic principles for the choices made regarding the independent and dependent variables used in the study; "Subjects", where the Authors insert the approval of their project by the control bodies, if any, and the appropriate informed consent obtained. All the characteristics of the subjects that are not dependent variables of the study are to be included in this section and not in the "Results"; "Procedures" includes the methods used, bearing in mind the concept of the possibility of a "replication of the study"; "Statistical Analysis", is the section that clearly states the statistical approach to the analysis of the series or of the data series. It is important to include the α level of significance (e.g., $P \leq 0.05$). Authors are requested to include in the paper the statistical power for the size and reliability of the measures used with intra-class correlation coefficient (ICC). Additional subtitles may be used, but their number must be as limited as possible.

C. Results. The results of the study are presented in this section. The most important findings must be presented in the form of tables and figures and the less important should be included in the text itself. Do not insert data that are not part of the experimental project or have been already published.

D. Discussion. In this section, the results of the study are elaborated. They must be related to the literature that currently exists; all hypotheses therefore must be covered.

It is recommended that statements such as "further research will be necessary, etc. etc... " be avoided.

Practical applications. In this section, it is essential to indicate to the coach or the sports professional how to apply and use the data contained in the article. It is a distinctive feature of *SM*, also in compliance with the editorial mission (see above), to try to bridge the gaps between the professional laboratory and the professional field.

5. Bibliography

All references must be listed in alphabetical order by last name of the first Author and numbered. References in the text must be made with numbers [e.g. (4, 9)]. All bibliographic entries listed should be cited in the paper and indicated by numbers. Please carefully check the accuracy of the bibliography, mainly to avoid - during the preparation of proofs - changes in bibliographic entries, especially regarding the numerical order in which the citations appear.

6. Acknowledgements

In this section, information may be included regarding identification of funding sources, updated contact information of the Author and acknowledgements to others involved in the execution of the experiment, if it was an experiment. In this part of the document, information must be included relating to conflicts of interest. In particular, the Authors should: 1) declare the professional relationship with other companies or producers who benefit from the findings of the study and 2) cite the specific grant funding in support of the study. Failure to disclose such information could result in the rejection of the article submitted for publication.

7. Figures

The legends of the figures should be submitted on separate pages, and each figure should appear on a separate page. Each work should be accompanied by a set of figures. Electronic photographs copied and pasted in Word and PowerPoint will not be accepted. The images must be scanned at a minimum of 300 *pixels per inch* (ppi). The Line art should be scanned at 1200 ppi. Please specify the file format of the graphs. TIFF or EPS formats will be accepted for both Macintosh and PC platforms. We also accept image files in the following native application file formats:

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Layout. Ensure that all figures and tables have been mentioned in the text. Indications must be given as to their position between paragraphs, for example: Figure 1 is to be inserted at this point, or the Table 1 in the latter; etc.

8. Tables

Tables should be typed double-spaced on separate pages and include a short title. Ensure that there is adequate space within the tables and use the least possible number of layout rules of the rows. When tables are necessary, the information must not be a duplicate of data already in the text. All figures and tables must include standard deviations or standard errors.

Costs for Authors

SM does not charge the Authors with any fees for presentation or per page. It is precisely for this reason that it is assumed that once the manuscript has been accepted for publication and sent to the printers, it is in its final form.

Terminology and measurement units

Under the terms of the Scientific Committee of *SM* and in order to promote uniformity and clarity in all scientific journals, the Authors are invited to use the standard generally accepted terms in the field of sports sciences and sports. The Scientific Committee of *SM* accepts the use of the following terms and units. The units used will be those of the International System of Units (SI). Exceptions allowed: heart rate: beats per minute; blood pressure: mm Hg; gas pressure: mm Hg. The Authors may refer to the British Medical Journal (1: 1334-1336, 1978) and the Annals of Internal Medicine (106: 114-129, 1987) to properly express other units or abbreviations. When using units of measurement, please place the multiplication symbol in the middle of the line to avoid confusion with a full stop; e.g. **ml • min-1 • kg-1.**

Among the simple units and those derived most commonly used in research reports of this magazine are:

Mass: gram (g) or kilograms (kg); force: Newton (N); distance: metres (m), kilometre (km); temperature: degree Celsius (° C); energy, heat, work: joule (J) or kilojoules (kJ); power: watt (W); time: Newton per meter (N • m); Frequency: hertz (Hz); pressure: Pascal (Pa); time: second (s), minutes (min), hours (h); volume: litre (l), millilitre (ml); and the quantity of a particular substance: moles (mol), millimoles (mmol).

Conversion factors selected:

- 1 N = 0.102 kg (force);
- 1J = 1 N • m = 0.000239 kcal = 0.102 kg • m;
- 1 kj = 1000 N • m = 0.239 kcal = 102 kg • m;
- 1 W = 1 J • s-1 = 6.118 kg • m • min.

When using the nomenclature for the types of muscle fibres, please use the following terms. The types of muscle fibres can be identified using the methods of histochemical classification or by gel electrophoresis. The histochemical staining of the ATPase is used to separate the fibres in the forms of type I (slow-twitch), type IIa (fast-twitch) and type IIb (fast-twitch). The work of Smerdu et al. (AJP 267: C1723, 1994) indicates that the fibres contain the type IIb myosin heavy chain type IIx (typing fibres by gel electrophoresis). To meet the need for continuity and to reduce confusion on this point, it is recommended that the Authors use IIx to indicate what were called IIb fibres (Smerdu V, Karsch-Mizrachi I, Champion M, Leinwand L, and S. Schiaffino , Type IIx myosin heavy chain transcripts are expressed in type IIb fibers of human skeletal muscle. Am J Physiol 267 (6 Pt 1): C1723-1728, 1994).

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EL TALENTO ATLÉTICO: FUNDAMENTOS METODOLÓGICOS
Vladimir Issurin
SM (Eng), n.º 11, año IV, septiembre-diciembre 2018, págs. 4-21
El texto constituye el primer capítulo de un libro del mismo autor, dedicado por completo al talento humano y a las modalidades de descubrimiento y de desarrollo de éste. Se presentan las posiciones y los conceptos fundamentales de la teoría del talento atlético; los estudios y los proyectos actualmente en curso o previamente realizados en diversos países por varios equipos de estudiosos y escuelas de pensamiento internacionales.

LA BIOMECÁNICA DEL SARCÓMERO COMO ORIGEN DE LA FUERZA MUSCULAR. PARTE II
Donato Formicola
SM (Ita), n.º 11, año IV, septiembre-diciembre 2018, págs. 22-33
Durante la contracción muscular, los iones de calcio entran en el sarcómero, se unen a la troponina, que mueve los filamentos de tropomiosina, lo que permite que las moléculas de actina se unan a los extremos móviles de la miosina y se produzca el acortamiento de la fibra muscular. En estos últimos 60 años de investigación biológica, se han presentado diferentes modelos biomecánicos para describir estas rápidas secuencias de acciones y reacciones musculares. Asimismo, se conoce cómo todo el sarcómero transforma su energía química en energía mecánica de contracción. No obstante, cómo pueda concentrar tal fuerza mecánica en los extremos sigue siendo objeto de estudio.
En el presente artículo se exponen las teorías más modernas sobre el modelo biomecánico de contracción del sarcómero, partiendo de los conceptos de hemisarcómero y de diferencial linear autobloqueante. Según estas teorías, la contracción de la célula muscular es la suma de los fenómenos biomecánicos que se generan en los dos lados de un mismo sarcómero de forma independiente.
Estos conceptos, además de inspirar el desarrollo de aplicaciones biotecnológicas innovadoras para permitir que las personas vivan la experiencia de la hiperfuerza, pueden explicar algunas de las respuestas fisiológicas anómalas que el tejido muscular manifiesta tras haber sido estimulado por un ejercicio excéntrico intenso.

EL PARADIGMA PNEI PARA LA ACTIVIDAD DEPORTIVA
Bruscolotti M., Chiera M., Barsotti N., Urso A.
SM (Ita), n.º 11, año IV, septiembre-diciembre 2018, págs. 34-45
La Psiconeuroendocrinoinmunología (Pnei) es una "disciplina que estudia las interacciones entre los sistemas corporales, entre el cuerpo y la mente, entre el organismo y el entorno físico y social", sustentándose en las últimas investigaciones de las neurociencias, la biología molecular y la epigenética, entre otras.
La actividad deportiva, dada su enorme variedad y la elevada carga psicofísica que impone a los atletas que quieren alcanzar los mejores resultados, representa un fenómeno complejo que merece ser abordado de la manera más exhaustiva posible. Estudiar la actividad deportiva a través de la visión de la Pnei, permite ver con claridad como, además de la mecánica y del clásico principio de todo tipo de entrenamiento "use it or lose it" ("úsalo o piérdelo"), existen otros muchos aspectos que influyen en el rendimiento y el estado de salud del atleta.
Por consiguiente, en este artículo mostraremos los vínculos desde la óptica Pnei del rendimiento deportivo con factores tales como la postura, la neuroendocrinología muscular, la nutrición y los ritmos biológicos.

IDENTIFICACIÓN DE UNA PRUEBA PARA EL SEGUIMIENTO DEL RENDIMIENTO EN HALTEROFILIA DE HALTERÓFILOS MASCULINOS Y FEMENINOS DE NIVEL COMPETITIVO
Travis S. K., Goodin J. R., Beckham G. K., Bazyler C.D.
SM (Ita), n.º 11, año IV, septiembre-diciembre 2018, págs. 46-57
Resumen: Es habitual realizar pruebas de seguimiento para evaluar la preparación de los levantadores de pesas para la competición. Aunque se han utilizado varias pruebas de seguimiento, todavía no se ha definido qué prueba es el indicador más consolidado del rendimiento en halterofilia. Por consiguiente, el objetivo de este estudio era (1) determinar la relación entre el salto vertical, la arrancada isométrica hasta medio muslo (IMTP, por sus siglas en inglés) y el rendimiento en halterofilia; y (2) comparar los saltos verticales con la IMTP como pruebas de seguimiento del rendimiento en halterofilia en una amplia cohorte de halterófilos masculinos y femeninos. Métodos: Cincuenta y dos halterófilos (31 hombres, 21 mujeres) participaron en pruebas de sentadillas con salto y saltos con contramovimiento (SJ, CMJ, por sus respectivas siglas en inglés) y pruebas de IMTP realizadas sobre una plataforma de fuerza. Todos los datos de las pruebas de laboratorio fueron correlacionados con una reciente competición en la que los atletas intentaron llegar al máximo. Resultados: la altura de las sentadillas con salto (SJH, por sus siglas en inglés) consiguió la mejor correlación en hombres y mujeres utilizando el coeficiente Sinclair Total ($r = 0{,}686$, $p \leq 0{,}01$; $r = 0{,}487$, $p \leq 0{,}05$, respectivamente) en comparación con la altura del salto con contramovimiento ($r = 0{,}642$, $p \leq 0{,}01$; $r = 0{,}413$, $p = 0{,}063$), la fuerza máxima de la IMTP aumentó alométricamente la masa corporal ($r = 0{,}542$, $p \leq 0{,}01$; $r = -0{,}044$, $p = 0{,}851$) y la tasa de desarrollo de la fuerza a 200 ms ($r = 0{,}066$, $p = 0{,}723$; $r = 0{,}086$, $p = 0{,}711$), respectivamente. Asimismo, la SJH mostró una correlación más evidente con el correspondiente rendimiento en halterofilia en comparación con la fuerza máxima de la ITMP en las mujeres ($p = 0{,}042$) pero no en los halterófilos hombres ($p = 0{,}191$). Conclusiones: Aunque el CMJ y la IMTP siguen considerándose unos indicadores importantes del rendimiento en halterofilia, la SJH parece ser la medida más orientativa del rendimiento en halterofilia en una amplia gama de niveles de rendimiento. Por consiguiente, puede utilizarse la SJH como medida fiable para llevar el seguimiento del rendimiento en halterofilia en halterófilos masculinos y femeninos.

AUMENTO DE LA MASA CORPORAL EN LA HALTEROFILIA: CONSECUENCIAS PARA LOS HALTERÓFILOS MÁS FUERTES DEL MUNDO
Andrew Charniga
SM (Ita), n.º 11, año IV, septiembre-diciembre 2018, págs. 58-69
El texto constituye el primer capítulo de un libro del El autor expone los problemas relacionados con el aumento y la disminución de la masa corporal a los efectos del resultado en el levantamiento de pesas. Propone una serie de consideraciones relacionadas también con los resultados obtenidos por los mejores levantadores de pesas masculinos y femeninos en las diferentes categorías de peso, y se recrea en los problemas de naturaleza técnica y de entrenamiento que se evidencian cuando la masa corporal aumenta y cuando, por el contrario, se deteriora progresivamente: todo ello a raíz de las nuevas normas reglamentarias como la introducción de la categoría de 90 kg en las mujeres, donde los resultados logrados por las atletas de alto nivel han sido, en general, inferiores a los alcanzados en las categorías de peso inferiores, por ejemplo, 75 kg e incluso menos.

Russian

СПОРТИВНЫЙ ТАЛАНТ: МЕТОДОЛОГИЧЕСКИЕ ОСНОВЫ

Vladimir Issurin

Статья представляет собой главу книги автора, полностью посвящённую таланту и методам его поиска и развития. Представлены позиции и основные понятия теории спортивного таланта; исследования и проекты изучения проблемы, которые в настоящее время реализуются или уже реализованы в различных странах разными интернациональными группами учёных и школами мысли.

БИОМЕХАНИКА САРКОМЕРА, ОСНОВЫ ПРОИСХОЖДЕНИЯ МЫШЕЧНОЙ СИЛЫ. ВТОРАЯ ЧАСТЬ (FORWARD ENGINEERING)

Donato Formicola

Во время мышечного сокращения ионы кальция проникают в саркомер, связываются с тропонином который двигает филаменты тропомиозина, что позволяет актинам связаться с двигательными терминалами миозина и реализовать сокращение мышечных волокон. В последние 60 лет в биологических исследованиях были представлены различные биомеханические модели с целью описания этих быстрых последовательностей молекулярных акций и реакций. Каким образом весь саркомер превращает свою химическую энергию в механическую эненргию сокращения это уже известный факт. Однако как саркомер в состоянии разделить подобную механическую силу на своих концах всё ещё является объектом изучения.

Настоящя статья хочет представить самые современные теории биомеханической модели сокращения саркомера, базируясь на понятиях полусаркомера (расстояние между линеей M и линеей Z) и линейного самоблокирующегося дифференциала. Согласно этим теориям, сокращение мышечной клетки это сумма биомеханических феноменов которые генерируются в двух сторонах одного и того же саркомера независимо друг от друга.

Эти понятия, помимо того что они вдохновляют на разработку инновационных биотехнологических исследований, позволяющих человеку испытать опыт сверхсилы, способны объяснить некоторые аномальные физиологические реакции мышечной ткани стимулированные интенсивными упражнениями уступающего (эксцентрического) характера.

ПАРАДИГМА ПНЕИ (PNEI) И СПОРТИВНАЯ ДЕЯТЕЛЬНОСТЬ

Bruscolotti M., Chiera M., Barsotti N., Urso A.

ПНЕИ (PNEI), аббревиатура термина Psico-Neuro-Endocrino-Immunologia (Психо – Невро – Эндокринная Иммунология) это “системная дисциплина основанная на молекулярной базе”, которая изучает взаимосвязи между системами организма, между телом и мозгом, между организмом и физической и социальной средой, основываясь на самых современных исследованиях неврологии, молекулярной биологии, эпигенетики и других наук.

Спортивная деятельность, учитывая её исключительное разнообразие и высокую психофизическую нагрузку необходимые для спортсменов стремящихся достигнуть высочяйших результатов, представляет собой очень сложное явление, которое заслуживает наиболее всестороннего анализа. Изучение спортивной деятельности “через линзу” ПНЕИ позволяет понять как, помимо механики и классического принципа любой тренировки “use it or lose it”, разнообразные аспекты влияют на производительность и результат и на состояние здоровья спортсмена.

Поэтому в этой статье демонстрируются, в ракурсе концепции ПНЕИ, связи между производительностью и такими факторами ка положение тела, мышечная нервно-эндокринология, питание и биологические ритмы.

ИДЕНТИФИКАЦИЯ МОНИТОРИНГОВОГО ТЕСТА ДЛЯ ОЦЕНКИ ПРОИЗВОДИТЕЛЬНОСТИ ТЯЖЁЛОАТЛЕТОВ (МУЖЧИН И ЖЕНЩИН) ВЫСОКОГО УРОВНЯ

Travis S. K., Goodin J. R., Beckham G. K., Bazyler C.D.

Мониторинговые тесты обычно используются для оценки готовности штангистов к соревнованиям. Несмотря на то что используется большое количество различных тестов ещё неясно какой тест является наиболее эффективным для оценки производительности в тяжёлой атлетике. Поэтому целью этого исследования является: 1) определение взаимосвязи между результатами в вертикальном прыжке, результатом в изометричекой тяге из полуприседа (IMTP) и результатом выполнения тяжёлоатлетических упражнений; 2) сравнение результата в вертикальном рпыжке и в IMTP как мониторингово теста для большого контингета тяжёлоатлетоа (мужчин и женщин). Методы: пятьдесят два тяжёлоатлета высокого уровня (из них 31 мужчины и 21 женщины) участвовали в тестировании в упражнении squat, SJ (приседания с отегощениями), в упражнении countermovement jump, CMJ (прыжок с противодействием) и в тестировании в упражнении IMTP на силовой платформе. Все результаты лабораторных исследований были сопоставлены с результатами достигнутыми в последних соревнованиях в которых спортсмены пытались достичь мвксимального результата. Результаты: высота достигнутая в упражнении Squat jump (SJH) показала очень высокую корреляцию (у мужчин и у женщин) при Sinclair Total (соответственно: $r = 0.686$, $p \le 0.01$; $r = 0.487$, $p \le 0.05$) с результатом (высотой) достигнутым в упражнении countermovement jump ($r = 0.642$, $p \le 0.01$; $r = 0.413$, $p = 0.063$), пиковой силой в упражнении IMTP аллометрически маштабированной с массой тела ($r = 0.542$, $p \le 0.01$; $r = -0.044$, $p = 0.851$) и скоростью развития силы в 200 ms ($r = 0.066$, $p = 0.723$; $r = 0.086$, $p = 0.711$). Кроме того, SJH показал очень высокую корреляцию с пиковой силой в IMTP у тяжёлоатлеток женщин ($p = 0.042$), но не у мужчин ($p = 0.191$). Выводы: хотя тесты CMJ и IMTP являются по прежнему высокими индикаторами для оценки производительности в тяжёлой атлетике, тест SJH является, по видимому, наиболее эффективным индикатором для тяжёлой атлетики в широком диапазоне показателей производительности. Таким образом, SJH может использоваться в качестве надёжного средства для контроля производительности в мужской и в женской тяжёлой атлетике.

ИЗМЕНЕНИЕ МАССЫ ТЕЛА В ТЯЖЕЛОЙ АТЛЕТИКЕ: ПОСЛЕДСТВИЯ ДЛЯ СИЛЬНЕЙШИХ ТЯЖЁЛОАТЛЕТОВ МИРА

Andrew Charniga

тестирования и даются квалифицированные инАвтор анализирует проблемы связанные с увеличением и уменьшением массы тела, реализованных с целью достижения высоких результатов в тяжёлой атлетике; представляет ряд соображений связанных с результатами достигнутыми лучшими тяжёлоатлетами (женщинами и мужчинами) в различных весовых категориях, с особым вниманием на проблемы связанные с техникой и с тренировочным процессом, которые наблюдаются когда масса тела увеличивается и, наоборот, когда она прогрессивно уменьшается: в том числе и в свете новых правил введённых для категории 90 кг для женщин, в которой результаты, достигнутые спортсменками высокого уровня были обычно ниже чем результаты достигнутые тяжёлоатлетками в более низких весовых категориях (например в категории 75 кг и даже в более низких).

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