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Front Pages

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The ***Athens Journal of Sports (AJSPO)*** is an Open Access quarterly double-blind peer reviewed journal and considers papers from all areas of sports and related sciences. Many of the papers published in this journal have been presented at the various conferences sponsored by the Sport, Exercise, & Kinesiology Unit of the **Athens Institute for Education and Research (ATINER)** & the Panhellenic Association of Sports Economists and Managers (PASEM). All papers are subject to ATINER's Publication Ethical Policy and Statement.

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The current issue is the third of the eighth volume of the *Athens Journal of Sports,* published by the Sport, Exercise, & Kinesiology Unit of the ATINER under the aegis of the Panhellenic Association of Sports Economists and Managers (PASEM).

Gregory T. Papanikos, President, ATINER.

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Knowing and Understanding how to Manage One's Physical Activity Practice: Contribution of Language, Thinking and Intelligence to Physical Literacy

By Paul Godbout[*]

Agreed upon components of physical literacy are (a) physical competence, (b) knowledge and understanding, (c) motivation and confidence, and (d) lifetime engagement. The purpose of this article is to discuss the development and use of the "knowledge and understanding" PL component in older students and adults with regard to the regulation of their health/fitness- and leisure-related physical-activity-practice (PAP). In a first section the author considers the pedagogical content knowledge (PCK) and the basic language that may be associated with the management of health- and fitness-oriented physical activities, differentiating elements that pertain to declarative, procedural or conditional knowledge. Based on exercise-monitoring procedures (E-MP) (essentially procedural knowledge) and on exercise-management rules (E-MR) (mostly conditional knowledge), the following section focuses on the development of PAP-management understanding and the related intelligence in its analytical, creative and practical dimensions. In a final section, the author explores briefly the matter of awareness and regulation in terms of exercise-management knowledge and understanding.

Keywords: *exercise-management awareness, exercise-management regulation, FITT formula, physical-activity monitoring*

Introduction

According to Whitehead (2013, p. 29) "physical literacy can be described as a disposition to capitalize on our human embodied capability, wherein the individual has: the motivation, confidence, physical competence, *knowledge and understanding* to value and take responsibility for maintaining purposeful physical pursuits/activities throughout the life course." Knowledge and understanding are two constructs regularly discussed in sport pedagogy, particularly in relations with the teaching/learning of team sports. In the above Whitehead's (2013) definition of physical literacy (PL), the two constructs encompass a much broader meaning. Among six attributes associated with making progress on one's individual/unique physical-literacy journey with intelligence and imagination, no less than four may be associated one way or the other with "knowledge and understanding" (Whitehead 2013, pp. 29–30, bold characters added by the author):

(1) **Sensitive perception in 'reading' all aspects of the physical environment, anticipating movement needs or possibilities and responding appropriately to these, with intelligence and imagination**.

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(2) A well-established **sense of self as embodied in the world**. This together with an **articulate interaction with the environment**, engenders positive self-esteem and self-confidence.
(3) **Sensitivity to and awareness of embodied capability**, leading to fluent self-expression through non-verbal communication and to perceptive and empathetic interaction with others.
(4) The ability to **identify and articulate** the essential qualities that influence the effectiveness of movement performance, and **an understanding of the principles of embodied health,** with respect to fundamental aspects such as exercise, sleep and nutrition.

Considering Whitehead's (2013) definition, the ultimate manifestation of PL is for an individual to maintain purposeful physical pursuits/activities throughout his/her life course. Taken literally, such a statement would imply an overwhelming amount of knowledge and understanding if it were to encompass utilitarian and non-utilitarian physical activities, regardless of their purpose and energy requirements. Going through Whitehead's (2013, p. 31) definition of physical illiteracy, one can work out the extent of PL as conceived by this author. In so doing, she appears to be describing a state of mind, a way of being, one way or the other. "Physically illiterate individuals will avoid any involvement in physical activity in all situations wherever alternatives are possible. This could include not walking short distances, avoiding tasks such as house cleaning and gardening, … Individuals will not be motivated to take part in structured physical activity …"

At the opposite, PL would encompass all participation in physical activity throughout the life course, being as valuable to the average performer and those with particular challenges to overcome, as it is to the most able. Coming back to the above mentioned ultimate manifestation of PL, the phrase "for an individual to maintain purposeful physical pursuits/activities" bears a strong significance: it is accepted from the start, or as a premise, that physical-activity (PA) literates exercise on purpose, hence the complexity of determining which knowledge and understanding are at stake. Performing physical activities in view of physical health and fitness, leisure, work chores, high performance, family chores, improving one's physical appearance, mental health, etc., or a combination of these are all plausible reasons for becoming or remaining physically active. Motives vary and may be basically intrinsic, somewhat extrinsic or internalized to various extents (Ryan and Deci 2020). Driven by different motives, PA literates may thus need to rely on diverse types of knowledge and possibly different levels of understanding.

Whatever particular field of knowledge is concerned with regards to physical activity, individuals need to grasp at least the basic terminology if they are to function with a reasonable level of autonomy (Wickens and Parker 2019). For example, in the context of tactical learning in team sports with a socio-constructivist approach, Godbout and Gréhaigne (2021) have discussed the development of game-play language and game-play intelligence, using knowledge and understanding as a background reference. The semantic process and constructs involved in solving PA-related challenges remains basically the same whatever the

activities concerned and despite the specifics of a particular PA area. Throughout their schooling, individuals are exposed to curriculum-content elements that cover PAs such as fundamental skills, sports, dance and creative movement, and fitness activities. Having developed an interest for particular communities of practice, older students (high school and college levels) may also wish to explore other activities related either to dance education, outdoor education, sport education (see Author's note 1 at the end of the article), or other recreation programs. Such a vast array of physical activities represents a considerable amount of content knowledge, way beyond the scope of an article. However, all these activities have in common the fact that they have an impact on the human body. A few years after reaching adulthood, individuals become gradually confronted with the emergence of a slow decline in terms of general physical fitness (Bonnie et al. 2015, Lumen learning team 2019). Unless they are prepared to face and react to these bodily changes, they may find it difficult to remain or become PA literate. In a study conducted with 291 middle-school students, Zhang et al. (2020) concluded that "[students'] incapability to engage in fitness-enhancing physical activities could be a result of lacking procedural fitness knowledge. Future school-based interventions may prioritize procedural knowledge learning for actual physical activity participation".

The purpose of this article is to discuss the development and use of the "knowledge and understanding" PL component in older students and adults with regard to the regulation of their health/fitness- and leisure-related physical-activity-practice (PAP) management. In a first section, the author considers the pedagogical content knowledge (PCK) and the basic language that may be associated with the management of health- and fitness-oriented physical activities, differentiating elements that pertain to declarative, procedural or conditional knowledge. Based on exercise-monitoring procedures (E-MP) (essentially procedural knowledge) and on exercise-management rules (E-MR) (mostly conditional knowledge), the following section focuses on the development of PAP-management understanding and the related intelligence in its analytical, creative and practical dimensions. In a final section, the author explores briefly the matter of awareness and regulation in terms of exercise-management knowledge and understanding.

Knowledge and Language with Regard to Health- and Fitness-Oriented Physical Activities

The distinction between declarative, procedural and conditional knowledge has become a classic in terms of knowledge-level categories (Schunk 2012). For instance, naming the components of the FITT formula (Frequency, Intensity, Time, Type; see Godbout and Nadeau 2021), an essentially recall exercise, would concern a piece of declarative knowledge. Any piece of information retrieved from memory belongs to the realm of declarative knowledge. Knowing how to measure one's heart rate would be representative of a piece of procedural knowledge: given a specific task or situation, this is how one should proceed. Knowing why and when implement a given procedure (e.g., increase the intensity or length of a bout

of exercise) is representative of conditional knowledge; it implies a higher level of understanding on the part of the performer. At each of these three levels of knowledge, understanding is at play. However, as we go from declarative to conditional knowledge, the complexity of mental processes, encompassed under the "understanding" label, increases.

There has been in the last quarter of a century an increasing interest for competence-based education (Klieme et al. 2008, Wesselink et al. 2010), starting with vocational education and training. The competence construct may be seen as a "context-specific cognitive disposition that is acquired by learning and is needed to successfully cope with certain situations or tasks in specific domains" (Klieme et al. 2008, p. 9). A relationship with the three categories of knowledge defined above is implicitly suggested by Escalié et al. (2019, p. 391) when they write "competence can be understood as an integrated and stable network of knowledge and know-how comprising normative behaviors, procedures and types of reasoning that students can use to manage complex situations". The notion of competence has also been used in Physical Education (e.g., Weiss 2011) and Health Education (e.g., Sudeck and Pfeifer 2016). In this article, in order to stay aligned with the "knowledge and understanding" PL component, the author will refer to diverse categories of knowledge as underlying support for PAP management competences.

Development and use of knowledge and understanding in any sphere of human experience require perception of one's reality and resorting to mental processes to assimilate or accommodate it. In that respect, fundamental capacities to be considered are language and intelligence; this last construct will be discussed later.

As is the case in sport activities, learning about the regular use of other physical activities in view of developing or maintaining one's physical fitness requires a certain mastery level of the related language. With regards to tactical learning in team sports, Godbout and Gréhaigne (2021, p. 53) wrote "during their debates or exchanges, learners resort back and forth to their everyday language, for general comments, and to game-play language for exchanges concerning subject-matter elements or tactical and strategic aspects of game-play". Accessing or providing relevant information about the management of PAP implies reading, exchanging or debating and thus, recalling and understanding the terminology associated with health-and-fitness content knowledge and its related pedagogical content knowledge (PCK) (Amade-Escot 2000).

Health and Fitness Pedagogical Content Knowledge

Considering the actual practice of PAs in view of developing and maintaining one's physical fitness (PF) directly involves two of the four PL components, *physical competence* and *lifetime engagement*. Thus, health- and fitness-related PCK may in a sense be associated with two dimensions of PA: (a) knowledge about motor and tactical skills specific to any PA likely to contribute to PF; and (b) knowledge about the proper management of the activity so that it may effectively have an impact on one's PF level. In this article, the author takes it for granted that

older students (senior high school and college level) and adults have developed, throughout their childhood and adolescence, a certain amount of motor and tactical skills either related to sports, dance and creative movement, muscular exercise skills, and/or outdoor activities, etc. Their experiences may have been restricted to PE classes or may have also have been associated with dance education, outdoor education, sport education, or other recreation programs on a community basis or a private one. The potential content knowledge and related PCK associated with such a large spectrum of activity is huge and beyond the scope of this article.

PCK targeted in the article relates to the way individuals may take advantage of one or many PAs to develop and/or maintain their PF through a lifetime engagement. This kind of knowledge does not focus on motor skills, nor on tactical skills in their usual sense. It rather focuses on the use and management of such skills, given the way one's body reacts to PA (Cale and Harris 2018, Edwards et al. 2017, Konukman et al. 2010). As the reader will see later, tactical decisions may be involved but in a different way. First and foremost, notwithstanding interactions with other people, exercise involves one's body functioning in a physical environment. Performing a physical activity produces acute effects on the body due to an increase of the metabolism involving different systems. Performing physical activity on a regular basis will also produce chronic effects on the long run. Management of one bout of exercise calls for knowledge concerning acute effects. Management of a prolonged series of exercise sessions calls for knowledge concerning chronic effects over time (several weeks, one season, one year for instance). While chronic effects usually relate to goal pursued, health benefits and potentially ill effects, acute effects reflect stimuli applied to our body along with related adjustments to bodily functions.

Health and Fitness Terminology

Table 1 presents in a nutshell a series of words or expressions related to PAP; although not exhaustive, it covers a spectrum fairly representative of the language used by people who exercise on a regular basis. The semantic map of fitness words suggested by Konukman et al. (2010) is a good example of such an exercise. This terminology, essentially declarative knowledge, refers to concepts (physical objects or phenomena) and constructs (creations of the mind) that older students and adults are expected to master and understand if they are to manage their PAP. In a way, this terminology represents a part of the PL language concerned with "maintaining purposeful physical pursuits/activities". Whenever individuals wish or need to debate, exchange about their PAP or read about it, mastering this terminology remains an essential requirement. Although technically declarative, part of this knowledge is, for many physically active individuals, an embodied or experiential kind of knowledge in the sense that they have an intimate acquaintance with these realities.

Table 1. *Terminology Related to Physical Activity Practice*

Body systems/Environment terminology	Related-concepts/constructs terminology (Words in **bold** characters are safety- or injury-related)
Cardiovascular system (heart and blood vessels)	aerobic, anaerobic, heart rate (resting, maximum), pulse, blood pressure, warm-up, cool-down
Respiratory system (lungs)	ventilation, heavy breathing, second wind, mild/moderate/intense shortness of breath, side stitch
Musculoskeletal system (muscle, ligament, tendon, bone)	muscle, ligament, tendon, bone, isotonic/isometric/eccentric exercise, warm-up, muscle fatigue, lactic acid, maximal strength, muscular endurance, muscular power, muscle fatigue, lactic acid, flexibility, stretching, delayed onset muscle soreness (DOMS), acute muscle soreness, **sprain**, **strain, tendinitis, overtraining syndrome (OTS)**
Skin	**sunburn**, **blister**
Thermoregulation system	sweating, wind factor, water loss, electrolytes, hyperthermia, **muscle cramps, heat exhaustion**, **heatstroke**, **dehydration, hypothermia**
Energy intake/expenditure	proteins, lipids (fat), carbohydrates, calories, oxygen intake, MET value
Environment factors	clothing, footgear, **allergies** (insects, plants), **frostbite**, wind chill factor, air temperature, humidity index, water temperature, **water pressure, bends,** altitude, **acute mountain sickness, hypoxia**

Verbalization facilitates reflection, observation and understanding by providing a database in view of exchanging with others. One must however differentiate the individual's construction of exercise-management knowledge and his/her acquisition of related language. For instance, when reading about or discussing about the measurement of one's heart rate, one should be familiar with and understand the meaning of the words heart, rate, pulse (or systolic waveform), artery, wrist or neck. Most older students and adults are familiar with these terms as part of the declarative knowledge cumulated over the years. Other terms or expressions such as temperature regulation, electrolytes, FITT formula, and so on, may represent new knowledge acquired through schooling or personal reading. Nowadays, this kind of knowledge may be accessed in textbooks intended for PE fitness classes (e.g., Corbin et al. 2014, Corbin et al. 2018).

As important as it may be, PL language is but a tool that makes it possible to understand the impact of physical activity and its management. Table 2 lists a series of exercise-monitoring procedures (E-MP) that may prove useful when planning or monitoring one's PAP; such procedures, equivalent to algorithms, should be considered as procedural knowledge. E-MPs related to heart rate can be found for instance in Corbin et al. (2014), Corbin et al. (2018), or similar publications. A simple procedure for computing one's PA volume has been discussed by Godbout and Nadeau (2021). For its part, estimating one's maximum muscular strength is possible by finding which weight an individual can lift (move) at least 5 times and no more than 10 times. For instance, if a person can lift

a 25kg weight 10 times and no more, the maximal strength of that person for the muscles concerned is estimated to be 33kg (Brzycki 1993, p. 89, Corbin et al. 2014, p. 211). Working with PE teacher-students of both genders, Godbout (1975) found that despite different maximal strength levels, men and women were able to perform similar numbers of repetitions at various percentages of their strength.

Table 2. *Exercise-Monitoring Procedures (E-MPs)*

• Determining one's heart rate (at rest, during exercise) (see Author's note 2)
• Computing one's percentage of Maximal heart rate
• Computing one's percentage of heart rate reserve
• Computing one's PA volume
• Estimating one's maximum muscular strength
• Estimating one's level of breathing
• Estimating one's level of sweating

Although they are not quantitative monitoring procedures, estimating the level of one's breathing and one's sweating may provide the performer with some information as to the extent of his/her bodily acute reactions to exercise with regard to exercise intensity (CSEP 2011) or environmental influential conditions. Targeted aerobic conditions of exercise will yield a steady-state pulmonary ventilation associated with medium or heavy (though controlled) breathing while anaerobic conditions will bring about an out-of-breath reaction and rapid cessation of exercise, a clear indication of a too intense level of activity unless the overload was intentional, like in cases of high-intensity interval training (HIIT) or high-intensity functional training (HIFT) (see Feito et al. 2018 for a distinction between these two forms of high-intensity exercising).

Another possible indicator of exercise intensity level sometimes mentioned is the level of perspiration. While not directly related to the intensity of the PA performed, it is associated with one's thermoregulation requirements, a bodily reaction associated with exercise, room or outdoor temperature, and humidity level, notwithstanding one individual's specific conditions associated with excessive sweating or lack of it. To the author's knowledge, there is no particular sweating or perspiration scale available in the literature; nonetheless, staying aware of one's level of perspiration during exercise remains an important subjective E-MP considering possible ill-effects such as dehydration and cramps (see Table 3).

Discussing tactical knowledge in team sports, Gréhaigne and Godbout (1995) and Godbout and Gréhaigne (2021) made a distinction between action rules and play organization rules, the former focusing more on game play per se while the latter delt with the way game play was managed. Analogically, one may think of E-MPs as action rules while organization rules would translate into exercise-management rules (E-MR). Table 3 presents typical topics for E-MRs. These managing rules should truly be looked at as conditional knowledge, pertaining to the "if … then" category of knowledge. Discussing the specifics of each E-MR would be beyond the scope of this article; interested readers, teachers, students and/or adults may consult guidelines such as the ones released by the Canadian

Society for Exercise Physiology (CSEP 2011, Tremblay et al. 2011) and by the U.S. Department of Health and Human Services (2018). Of particular interest in these publications is the fact that several categories of people are considered, a recognition of the importance of regulating exercise-management based on individuals' various needs at different periods of their life. Information provided by textbooks on fitness development and control (e.g., Corbin et al. 2014, 2018) may be of interest as well. Accessing this level of knowledge implies understanding and critical thinking on the part of a PA-literate individual as we will discuss in the next section of the article. Readers will note that several of the topics included in Table 2 and 3 may be associated with the "control competence" or the "self-regulation competence" identified in the Physical Activity-related Health Competence model (Carl et al. 2020, Sudeck and Pfeifer 2016).

Table 3. *Typical Topics for Exercise-Management Rules (E-MRs)*

- Managing the FITT formula
- Managing APR pattern (Activation, Performing stage[1], Recovery)
- Managing safety measures (clothing and footgear, weather [heat/cold/humidity], food/liquids, sun conditions, outdoor allergies, proper equipment, overloading risks[2])
- Managing outdoor environment (footgear and terrain, clothing and weather)
- Managing weather conditions: temperature, humidity, hydration, sunburns
- Managing reversibility[3] and getting back to exercising
- Managing muscle cramps or side stitches
- Managing diminishing return[3]
- Managing exercise overload[3] and signs of overtraining syndrome

[1]Made of continuous, short-interval and/or long-interval exercise.
[2]See Author's note 3.
[3]See Gannon (2004, section 2).

Understanding and Intelligence with Regard to Health- and Fitness-Oriented Physical Activities

From a constructivist perspective, becoming self-directing and self-actualizing with regard to one's PAP (Klesius 1971) implies understanding and thinking on the part of this individual, two characteristics related to intelligence (Godbout and Gréhaigne 2021). The building-knowledge process, as opposed to the acknowledging process, is paramount in light of understanding. Related mental processes should eventually lead to the development of PL intelligence.

Understanding the Mechanics of Regular Physical Activity Practice

Beyond a first level of understanding related to language assimilation, students' or adults' challenge remains to understand the notions of E-MRs and E-MPs listed in Tables 2 and 3 and to make them their own either through assimilation or through accommodation (see Godbout and Gréhaigne 2021, pp. 48–49, for a summary of the knowledge-construction process though assimilation,

accommodation and adaptation). While assimilating includes storing knowledge, either declarative or procedural, into one's memory, accommodation means adjusting the theory of acute and/or chronic effects to one's reality through (a) reflection on the effects experienced , (b) hypotheses about possible consequences of new patterns of activity or particular adjustments to familiar ones, and (c) verification of and reflection on obtained results. An additional level of understanding is displayed when the individual can apply the management of one activity to another one and obtain similar results. In such cases, we will consider that the individual has adapted. As is the case with PL language discussed earlier, understanding E-MRs goes beyond a simple cognitive process. Through accommodation and adaptation, PA literates make such rules their own, embodying knowing and understanding.

While understanding physical activity has often been discussed with regard to tactical learning in team sports (e.g., Godbout and Gréhaigne 2021, Nadeau et al. 2020, Ramos et al. 2020, Zerai et al. 2020), it is quite possible to analogically associate PA-management decision-making to the use of tactics and strategy. Planning long-term PA projects (over one season or one year, for instance) calls for strategic choices: registering into a fitness program; buying particular pieces of equipment, clothing and/or footgear; etc. As time goes by, particular constraints may arise, calling for adjustments that require tactical thinking. When applying management rules, individuals will use convergent thinking (Godbout and Gréhaigne 2021) if they are familiar with the principles and decisions involved; through analyzing, evaluating, judging, comparing and contrasting, convergent thinking focuses on problem solving based on known procedures. Should individuals encounter an unfamiliar problem or look for different solutions to a familiar problem, they will likely resort to divergent thinking to imagine, create, invent solutions and verify their appropriateness (Godbout and Gréhaigne 2021). For instance, one may think that choosing to go jogging with a baby or an infant in a stroller, to go cycling while pulling a bicycle trailer, or to go running tied to one's dog are examples of solutions originally found through divergent thinking. Putting a T-shirt on to go snorkeling on a sunny day is another example of divergent thinking related to one's safety. Walking down a mountain slope in zig-zag to avoid an excessive amount of eccentric contractions in the thighs and consecutive DOMS the day after is again another example of divergent tactical thinking; and on, and on. Necessity is the mother of inventions; that often goes for exercise management, provided that safety measures are taken. The individuals' capacity for planning and adjusting their PAP, whatever circumstances arise, rests on their PL intelligence.

Developing PL Intelligence in Terms of Exercise Management

Theorizing about intelligence is not the purpose of this article. It seems nevertheless useful to provide readers with a few basic considerations followed by a discussion on the development of PL intelligence as it relates to exercise management.

Theoretical Considerations

Discussing game-play intelligence, Godbout and Gréhaigne (2021) resorted to an operational definition offered by the French *Centre national de ressources textuelles et lexicales* (2020). They wrote (Godbout and Gréhaigne 2021, p. 9):

> in new circumstances for which instinct, learning or habit has no solution, [intelligence is] the *aptitude* for (a) grasping (comprehending) and organizing situational data, (b) putting together procedures to be used and the final aim, (c) choosing appropriate means or (d) discovering original solutions that will allow an adaptation to the requirements of the action. … Followed by a complement referring to an activity [PAP management, for example], the word intelligence is defined as an aptitude, a particular capacity, a gift for the activity concerned.

Thus, one may consider intelligence as an aptitude or a particular capacity whose development depends on the amount of knowledge, concepts and conceptual networks cumulated and understood by a person.

In this article, the author will consider PL intelligence, in terms of exercise management, as an individual's capacity to use both strategic and tactical thinking to manage his/her PAP given acute and chronic effects pursued.

PL Intelligence in Terms of Exercise Management

Based on Sternberg's (1985, 2005) theory of intelligence, the author will use the notions of analytical, creative and practical intelligence. Analytical intelligence is at work when a person analyzes, evaluates, judges, or compares and contrasts. It may therefore be associated with convergent thinking which focuses on problem solving based on known procedures. For its part, creative intelligence enables individuals to invent or imagine one or different solutions to a new problem; it manifests itself through divergent thinking as defined above. Finally, through practical intelligence, individuals apply their abilities to the kinds of problems that confront them in daily life. Practical intelligent people adapt, shape or select environments. "Adaptation is involved when one changes oneself to suit the environment. Shaping is involved when one changes the environment to suit oneself. And selection is involved when one decides to seek out another environment that is a better match to one's needs, abilities, and desires" (Sternberg 2005, p. 193). One may consider that convergent or divergent thinking is involved depending upon which particular situation arises.

Applying E-MRs listed in Table 3 implies, on the part of the PA literate, the learning of a vast amount of knowledge, be it declarative, procedural or conditional. Beyond the understanding of concepts and multiple constructs, individuals must develop conceptual networks involving combinations of specific pieces of procedural knowledge. The management of the FITT formula is particularly representative of PL intelligence at work, calling for joint and simultaneous decisions about the intensity, duration, frequency and type of exercise, all this taking into account the weather conditions and the particular physical environment in which the exercise will take place. Some of the E-MRs to

be applied may rely on practical intelligence (selecting proper gear for a given environment or selecting a proper environment given the gear at one's disposal for instance). Other E-MRs are more complex and require either analytical or creative intelligence.

Two of these E-MRs offer a regular and systematic challenge to the performer: (a) managing the FITT formula; (b) managing APR pattern (activation, performing stage, recovery). In a sense, these two rules may be seen as advanced organizers either for the learner or the adult PA literate. On the one hand, as mentioned earlier, the application of the FITT formula always calls for decisions regarding frequency (F), intensity (I), time (T), and type of activity (T) (readers may consult Godbout and Nadeau 2021 for a more elaborate discussion on that topic). On the other hand, the APR pattern may also be considered an advance organizer in the sense that, whatever the bout of exercise and despite possible variations of stimulus-intensity, a person will always depart from a resting state, experience an increased activity of various body systems until cessation of exercise, and go through recovery until resting state is restored. Within the parameters of each of these advance organizers, the performer will use one type of intelligence or another (mostly analytical or creative) to make decisions and come up with plans of actions. For instance, a person may choose, through creative intelligence and divergent thinking, to experience all kinds of variation of intensities during the performance stage of the APR pattern, using continuous, short-interval, long-interval phases or some combination of them. At times, natural features of the physical environments may provide such varied conditions. Although not so systematic in its application, the managing-safety-measures rule plays the role of advance organizer as well. This particular E-MR covers several "if … then" propositions associated with varied aspects of PA such as thermoregulation (e.g., if hot weather, drink more; if heavy sweating, restore body electrolytes to avoid cramps), clothing and footgear (e.g., if the exercise may cause hand blisters, wear protection gloves; if jogging elicit foot problems or shin splints, look for proper running shoes; if cold weather, wear layers of clothes with synthetic inner layer to let the sweat pass through the fabric), etc.

Incorporating E-MRs into one's regular PAP implies an awareness and some level of regulation of one's exercise-management knowledge and understanding.

Exercise-Management Knowledge and Understanding: Awareness and Regulation

Godbout and Nadeau (2021, p. 13) stated that "awareness of one's knowledge and understanding means that the individual knows to what extent he/she understands the principles of regular PA regarding the FITT formula, the acute and chronic effects of exercise, etc." Awareness of one's exercise management goes a step further in the sense that the PA literate should take notice of the way he or she applies the various E-MPs and E-MRs presented in Table 2 and Table 3. Failure to apply these procedures or these rules properly may be indicative of a lack of related knowledge, a lack of understanding, and/or the need for further conceptual development. As individuals become more self-directing and self-actualizing (Klesius 1971), self-regulation of exercise management ought to set in. Through

the development process of autonomy, co-regulation scenarios may well play an important role (see Godbout and Nadeau 2021, for an elaborate discussion of co-regulation and socially shared regulation associated with PAP regulation).

Whatever particular type of regulation is concerned, some form of monitoring is required (Godbout and Gréhaigne 2020). Besides using formal monitoring procedures evoked in Table 2, individuals may also take advantage of natural clues provided by their body throughout the APR pattern alluded to earlier. Any activation/performing/recovery triad produces various acute effects. Three bodily adjustments easily noticeable are (a) variations in the heart rate, (b) variations in breathing, and (c) appearance of sweat. Noticing a significant increase in breathing and medium to heavy sweating (Tidén et al. 2021) is simply a matter of common sense. For its part, heart rate may be easily monitored by hand (see Corbin et al. 2014, pp. 166–167, for instance) or can be determined with the help of wearable electronic devices. Should the cardiovascular, respiratory or thermoregulation system fail to increase noticeably, there is cause for adjustment of the FITT formula.

Contrary to the management of the APR pattern and of the FITT formula, other aspects of PAP management do not necessarily call for systematic regulation, although preventive monitoring remains advisable. This is the case for management rules pertaining to safety since acute effects may have negative consequences (e.g., dehydration, sunburns, blisters); some chronic effects may also lead to injuries (a most frequent one being the tendinitis). Should an individual tend to suffer from exercise-related ill-effects on a regular basis, this would mean that the person is not managing properly his/her PAP and needs to develop further knowledge and understanding. Finally, other aspects of management regulation may be called for, depending upon particular constraints that occur in one's everyday life, or upon life changes freely implemented by people.

Limitations

As briefly mentioned in the introduction, knowledge and understanding discussed in this article do not relate to the specifics of every physical activity that can be considered by individuals when planning their PA practice. Each category of activity, if not each activity in itself, may be studied, discussed and learned based on a specific content knowledge and its related logic, understanding and language. Not even a single book could consider so much information. Knowledge and understanding considered above is limited to the management, or regulation, of one's PAP, whatever the particular activity might be, considering the acute and chronic effects of exercise on the human body. It is likely that one's PAP bears also consequences psychologically and socially; these dimensions of the impact of PAP have not been examined, not only for lack of space but for lack of knowledge as well on the part of the author.

Conclusion

This article has discussed PL PCK, language, and intelligence as they relate to exercise management. Three other PL components were not specifically taken into consideration; they are physical competence, motivation and confidence, and lifetime engagement. Motivation and lifetime engagement have been discussed in line with a constructivist approach (Godbout and Nadeau 2021) and the author elected not to consider physical competence related to specific physical activity, given the bulk of PCK content involved and the fact that the article targets older students and adults who have likely developed a significant base of physical competence throughout the years and/or can still choose to develop new PA competences on their own within the community. Intelligent management of PAP calls for people to use knowingly E-MPs and E-MRs conducive to sound self- and/or co-regulation. In the perspective of preparing older students for an autonomous and self-regulated lifetime PA engagement, PE teachers ought to target their students' development of PAP-management related language and intelligence.

Author's note 1. In this article, "sport education" does not refer to Siedentop's (1994, 1998) instructional model. It refers to children's, adolescents' and older students' educational experiences in out-of-PE- lessons sport programs offered them under the form of intramural and interschool competition, community-led sport leagues programs, specialized summer camps, etc. Through coaching, PE-trained educators and other sport educators contribute largely to the participants' sport education.

Author's note 2. Despite the fact that smart mobile devices such as smartwatches make it easier for performers to monitor their heart rate, older students and active adults should still understand the mechanics of the procedure as a way to embody their knowledge concerning acutes effects of exercise.

Author's note 3. There has been in recent years an increased interest for high-intensity interval training (HIIT) and high-intensity functional training (HIFT) exercises (Feito et al. 2018). Such exercises should be performed with proper preparation due to higher risks of musculoskeletal injuries (Rynecki et al. 2019).

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An Analysis of Coaches' Perceptions of Inappropriate Coaching Behaviors

By Brad Strand[*]

The use of inappropriate coaching behaviors has been an ongoing concern for many years. However, not yet well researched is the use of inappropriate and bullying behaviors by coaches toward student-athletes. The purpose of this study was aimed at gathering relevant information on coaches' use of inappropriate behaviors towards athletes, as reported by coaches. Participants for this study included 488 public/private school sport coaches, males (N=332) and females (N=153), from eight states. Data were gathered via an on-line survey in which participants identified if they had engaged in any of 22 listed actions among three types of bullying (physical, relational, verbal). Participants identified three actions ('poking fun at an athlete', 'embarrassed an athlete in front of others', and 'name calling without hurtful intent') as having been done by at least 30% of them. In summary, most actions were reported to have not been used by most coaches, three-fourths of the actions were considered inappropriate, and less than half were considered bullying.

Keywords: *coaching, bullying, sports*

Introduction

In 2015, Wolff published an article in *Sport Illustrated* titled, "Is the era of abusive college coaches finally coming to an end"? Within the article the author presented a list of major college coaches who had been accused of abusing athletes. The list included Bobby Knight at Indiana, Tim Beckman at the University of Illinois, Greg Winslow at the University of Utah, and Erin Layton at the University of Rhode Island. The story came in the aftermath of video showing Mike Rice of Rutgers physically and mentally abusing his basketball players. Has much changed since then? One would hope so, but just in the past year basketball coaches at Detroit Mercy (Wimbley and Komer 2021), Texas Tech (Pao 2020), and Purdue-Fort Wayne (Benbow 2021) have been accused of abusive behavior towards their athletes.

Bullying, abuse, and inappropriate behavior have long been a topic of emphasis in k-12 school settings (American Educational Research Association 2013). However, does that emphasis carry over to school sponsored extra-curricular activities, e.g., athletics? And if so, does it only focus on the behavior of students or are coaches included too? Although numerous studies have reported on positive youth development through sport (Fraser-Thomas et al. 2005, Turnnidge et al. 2014, Vella et al. 2011, Vierimaa et al. 2012), the athlete-coach relationship (Dominteanu 2011, Jowett and Cockerill 2003, Poczwardowski et al. 2006), and perceived poor coaching (Gearity 2012, Gearity and Thompson 2011); few studies

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have actually investigated inappropriate coaching practices in high school sport settings (Alexander et al. 2011, Shields et al. 2005, Strand et al. 2017, Swigonski et al. 2014, Yukhymenko-Lescroart et al. 2015), and for the most part, these studies are from the athletes' perspective.

Coaches interact with their athletes on a daily basis in practice, and in many instances, throughout the school day. These in-school interactions involve talking about the team, other athletes, opponents, practices, past games, and upcoming games in a somewhat equal social setting. When the school bell rings ending the school day, the teacher becomes a coach and the student an athlete. Both individuals assume different roles in different settings. Interactions and communication take on different meanings in the context of practice and games. What a teacher/coach says jokingly in the hallway to a student/athlete is easily interpreted differently on the practice field or court. Many athletes validate themselves through their sport performance and this becomes their identity (Burns et al. 2012, Ronkainen et al. 2016, Ronkainen and Ryba 2019). Insensitive comments in practice settings carry a lot more weight than those said outside the confines of practice, and athletes respond differently to those comments.

With that background as a preface, this study was aimed at gathering relevant information on coaches' use of inappropriate behaviors towards athletes as reported by coaches. The following research questions guided the study:

- As a coach, have you ever done the identified action to an athlete?
- Do you think this is an inappropriate coaching action?
- Do you consider this action bullying?

Methods

Participants

Members of state coaches associations in eight midwestern states completed a 22-item survey that included a listing of actions described as bullying. Potential subjects received an email inviting them to participate in the survey. The email was distributed to coaches via an email sent from an identified colleague within each of the state associations. The email included an informed consent and a link to the survey. Data were collected via a Qualtrics survey. In additional to the usual demographic information, participants were asked to indicate if; 1) if they had ever done this action to an athlete, 2) if they think this is an inappropriate coaching action, 3) if they consider this action bullying, and, 4) if they had stopped doing the action when they knew it was inappropriate.

Participants were 488 public/private school coaches, males (*N*=332, 68.5%) and females (*N*=153, 31.5%) from eight states (MO, NE, ND, MN, KS, IA, SD, MS). The ethnic composition of the sample was largely White/Caucasian (92.3%), followed by Black American (4.3%), Hispanic (0.4%), Native American (1.4%), Asian/Pacific Islander (0.2%), and Multiple ethnicity/other (1.0%). One-half of the participants had earned a graduate degree. By age, 14.9% were aged 20-30, 22.6% were aged 31-40, 25.9% were aged 41-50, 25.0% were aged 51-60, 9.4% were

aged 61-70, and 2.0% were older than 70. By degree, every participant had obtained a high school degree or GRE; 99.6% had attended some college; 93.8% had obtained a BS degree; and 47.2% had earned a graduate degree. By occupation, 78.4% were employed as school teachers.

Measures

Table 1. *Coach Behaviors*

Coach Behavior with Type and Degree	Have you ever done this to an athlete?	Do you think this is an inappropriate coaching action?	Do you consider this bullying?
1. Hit, slapped or heckled an athlete with intent to hurt (P, M)	2.3%	82.4%	64.8%
2. Threw something at an athlete (P, M)	9.8%	77.3%	45.3%
3. Threw something at an athlete with intent to hurt (P, Mo)	0.8%	80.1%	60.9%
4. Struck an athlete with equipment (P, Mo)	3.7%	78.9%	54.3%
5. Physical violence to deliberately inflict pain on an athlete (P, S)	1.0%	82.0%	62.1%
6. Locked an athlete in a room (P, S)	0.8%	81.6%	60.5%
7. Inappropriate unwanted touching towards an athlete (P, S)	1.6%	82.0%	49.4%
8. Critical comments meant to hurt an athlete (R, M)	6.6%	77.0%	56.1%
9. Dirty look meant to hurt an athlete (R, M)	13.7%	70.3%	43.0%
10. Embarrassed an athlete in front of others (R, Mo)	34.0%	61.3%	41.6%
11. Set an athlete up to look foolish (R, Mo)	7.6%	75.8%	49.2%
12. Mild ethnic slurs towards an athlete (R, Mo)	2.0%	80.9%	57.4%
13. Hurtful ethnic slurs towards an athlete (R, S)	1.0%	81.1%	60.2%
14. Shunning an athlete from the team (R, S)	5.7%	75.0%	50.6%
15. Obscene gestures toward an athlete (R, Mo)	1.8%	81.1%	51.8%
16. Poked fun at an athlete (V, M)	44.9%	43.0%	25.4%
17. Inappropriate language towards an athlete; comments on sexual preferences (V, M)	3.1%	80.5%	51.6%
18. Name calling without hurtful intent (V, M)	30.9%	50.4%	26.2%
19. Name calling with hurtful intent (V, Mo)	1.6%	81.1%	61.3%
20. Verbal threats of aggression towards an athlete (V, Mo)	2.5%	79.7%	58.8%
21. Use of nickname when asked not to (V, M)	6.1%	74.8%	45.1%
22. Taunting at athlete (V, Mo)	3.3%	78.7%	54.5%

Type: Physical (P), Relational (R), Verbal (V).
Degree: Mild (M), Moderate (Mo), Severe (S).

The survey used for this study contained eight questions. Question one asked participants to review the (twenty-two) actions shown in Table 1 and indicate if: 1) if they had ever done this to an athlete, 2) if they think this is an inappropriate coaching action, and 3) if they consider this action bullying. As seen in the table, each action can be further defined as physical, verbal, or relational, and as mild, moderate, or severe.

The twenty-two items that were evaluated came from an inventory titled "Bully-Spotter: What is Bullying in Sports?" (Haber 2004). Haber's original Bully Spotter included fifty-three items categorized as physical, relational, or verbal bullying and then as mild, moderate, or severe in nature. The Bully Spotter was initially designed to be used to identify student-to-student bullying. For our purposes, we elected not to include all the items because many are student-to-student actions, for example, towel snapping, taking possessions (clothing, equipment, etc.), blame-placing, and gossiping. This inventory has been used in previous research (Strand et al. 2017). Demographic questions asked about gender, years of coaching experience, age, highest degree or level of school completed, racial background, if they were a k-12 teacher in addition to coaching, and the state in which they coached.

Procedures

Upon University Institutional Review Board approval, the questionnaire was formatted into the online data collection system known as Qualtrics. Colleagues in eight different states were asked to email the survey invitation to coaches in their respective states. All individuals who participated were current coaches. Each participant receiving the email was initially invited to participate in the study by opening a link that informed the recipient of the purpose of the study and content. In this same document, each participant was given the option to proceed with the survey by clicking a link to the actual survey. Clicking the link also indicated implied consent to participate in the study. The Qualtrics document was designed to accept only one response from each participant.

Data Analysis

All data were initially collected via Qualtrics. At the end of the data collection period, data were transferred to Statistical Package for the Social Sciences (SPSS, version 27) for further analysis. The methods applied were means and frequency distributions, cross tabulations, Pearson correlation tests, and Chi-square tests.

Results

Four hundred and eighty-five (485) coaches completed the survey. Table 1 reports the percentage of coaches who reported they had done the described action to an athlete, who think the action is inappropriate, and who think the action is bullying. Statistical analysis was conducted based on gender (male, female), years

of coaching experience (1-10, 11-20, 21-30, 30+), degree (no degree, BS degree, graduate degree), and occupation (school teacher, not a school teacher).

Have you ever done this to an Athlete?

Three actions were identified by participants as having been done by at least 30% of them. The most frequently reported action of a coach to an athlete was 'poking fun at an athlete' (44.9%). The second most frequently reported action of a coach to an athlete was 'embarrassed an athlete in front of others' (34.0%). The third action with more than 30% reporting they had done was 'name calling without hurtful intent'. Of the 22 actions, less than 10% of the participants reported they 'had done this action' to an athlete for 19 of the actions; and more specifically, less than 5% of the participants reported they had done this to an athlete for 13 of the actions.

Fishers exact test found significant differences by gender for five of the actions. For each of these actions, male responses were significantly higher than those of females: 'struck an athlete with equipment' ($p=0.043$); 'embarrassed an athlete in front of others' ($p=0.000$); 'set an athlete up to look foolish' ($p=0.024$); 'poked fun at an athlete' ($p=0.004$); and 'name calling with hurtful intent' ($p=0.000$). An ANOVA found no statistical significance differences based on years of coaching experience. Based on degree, a Chi Square revealed statistical difference for two actions, 'embarrassed at athlete in front of others' ($p=0.004$) and 'name calling with hurtful intent' ($p=0.033$). In both cases, participants with no degree reported doing these actions more than those with a college degree. Based on occupation, a Chi Square found significant difference for one statement, 'embarrassed an athlete in front of others' ($p=0.004$). Results revealed that teachers were more likely to do this than non-teachers.

Do you think this is an Inappropriate Coaching Action?

Approximately 55-60% of participants considered 21 of the 22 actions as an inappropriate coaching action. The only action with less than 50% support was 'poked fun at an athlete' with 43% who indicated they thought this action was inappropriate. For 10 of the actions, over 80% of participants indicated they thought the action was an inappropriate coaching action.

Fishers exact test found significant differences by gender for one of the actions, 'struck an athlete with a piece of equipment' ($p=0.031$). Females were more likely to think this was inappropriate than males. An ANOVA found statistical significance based on years of coaching experience for two actions, 'inappropriate unwanted touching towards an athlete' ($p=0.044$) and 'verbal threats of aggression towards an athlete' ($p=0.028$). For both actions, participants with 30+ years of experience differed from those with 11-20 years of experience ($p=0.045$ and $p=0.036$, respectively). In both instances, the more experienced participants were less likely to think the action was inappropriate. No significant differences were noted based on degree and occupation.

Do you consider this Bullying?

The percent of participants who considered the actions as bullying ranged from 25.4% for 'poking fun at an athlete' to 64.8% for 'hit, slapped, or heckled an athlete with intent to hurt'. For all of the actions considered, barely half of participants indicated they considered the action bullying for 14 of the statements. For the other eight statements, less than half considered the action as bulling.

Fishers exact test found significant differences by gender for two of the actions. For each of these actions, females were more likely to identify the action as bullying: 'shunning an athlete from the team' (p=0.016) and, 'inappropriate language towards an athlete' (p=0.034). An ANOVA found statistical significance differences based on years of coaching experience for three of the actions: 'mild ethnic slurs toward an athlete' (p=0.031), 'hurtful ethnic slurs towards an athlete' (p=0.037), and 'name calling with hurtful intent' (p=0.041). In all three instances, the differences occurred between participants with 1-10 and 30+ years of experience. Participants with 30+ years of experience were less likely to consider the action as bullying (p=0.024, p=0.024, and p=0.023, respectively). Based on occupation, a Chi Square found significant difference for five statements, 'threw something at an athlete' (p=0.041), 'dirty look meant to hurt an athlete' (p=0.012), 'embarrassed an athlete in front of others' (p=0.015), 'name calling without hurtful intent' (p=0.014), and 'verbal threats of aggression towards an athlete' (p=0.043). Results revealed that teachers were more likely than non-teachers to consider the first two mentioned actions as bullying while nonteachers were more likely to identify the other three actions as bullying. No significant differences were noted based on degree.

Participants' Comments about Actions

For each of the actions, participants were offered an opportunity to provide comments. For most of the actions, no comments were provided or a simple "no', "never". However, for some of the actions, participants provided more extensive comments; often providing clarification or perhaps justification for doing the action. In addition, the most comments were provided for the actions that were identified as having occurred most often. What follows are examples of comments for select actions.

<u>Poking Fun at an Athlete</u>

Coaches who commented said their poking fun at an athlete was just that, fun. One coach said, "Sometimes you have to be able to laugh at yourself when you goof up. So in this instance, I've probably made fun of an athlete (and myself) when he (or myself) has done something silly. I would not do this to intentionally hurt an individual." Another said, "all in good fun, was ok with athlete." A third said, "Knowing your athletes is important...having fun is important too....humor is contagious as long as you do not hurt the athlete." One said it was used as means to relieve tension and another said it was only used with athletes that he had a great rapport with."

A number of coaches did talk about the fine line of going too far with poking fun at athletes. One said, "If it gets out of hand and is repeated quite a bit, this would be bullying. However, I think poking fun at them in the right way can get their attention." Another said, "There is a line here. It is hard to define where it goes from showing acceptance (friendly ribbing) and where it is hurtful. Sometimes it is well intended but misinterpreted. If I felt I was misinterpreted I would apologize and attempt to make amends."

One coach excused it by saying, "Never meant to hurt feelings. Any new person that joins my team, I inform them that I am sarcastic."

Struck an Athlete with Equipment/Thrown Anything at an Athlete

The coaches who commented on striking an athlete with equipment generally did so a part of a drill or just having fun. One participant stated, "hitting them with whistle on helmet, messing around, the kids know this". Another said, "Depends. We use blocking pads and other devices to simulate game atmosphere. Sometimes we make things difficult, but we never do it with an intent to harm or hurt an athlete." A third said, "Basketball drills where we work on finishing a layup through contact. Student gets "hit" with a blocking pad."

The coaches who commented on throwing anything at an athlete, responded they had done this, "in a joking manner", "to get their attention", "to focus attention", "in good fun", and "only as a training tool".

Embarrassed an Athlete in Front of Others

For this action, coaches explained it as something that can be used to draw attention to inappropriate athlete behavior or to help change behavior. For example, "Sometimes this is an effective way to get the athlete's attention. However, if done repeatedly and with malicious intent, it would constitute bullying." Another said, "I have called an athlete out regarding inappropriate behavior he was publicly exhibiting in front of the team at that moment. In, doing so the athlete was likely embarrassed by the attention it drew." A third said, "This is something I used to do to invoke change, but I realize that one on one is much more effective and better. Correction is still sometimes done, but embarrassment is never the goal".

Two coaches said they couldn't control what embarrassed an athlete. One stated, "Whether or not the athlete is embarrassed is only something the athlete knows and can control, I have called out athletes for lack of effort, failure to listen, or for letting down other athletes -- I would assume that at times some have been embarrassed" Another stated, "Yes, this is different for each kid. What embarrasses one athlete, might not another. Intention is an embarrass but a side effect." One coach said that he had done this, but only a few times on purpose, and when he realized he had embarrassed an athlete, which wasn't his intention, he would apologize for his actions.

Set an Athlete up to Look Foolish

Coaches tended to explain this action as something they did to help an athlete(s) better understand that what they were doing was incorrect. One coach

said he set an athlete up to look foolish, "only when this athlete was acting in a way that they were better than others so to set up a scenario where they would realize they were not any better than the others." Similarly, another said, "Sometimes players feel as though they have a technique that may work out. Rather than correct it, we let them try it to see it fail. It makes them realize that there is a different way. Making them look foolish on purpose to demean them is bullying."

A third said, "If the athlete has been cocky, I try to have them not as cocky." A fourth said, making them look foolish, "sets the tone when there is a player who wants to do his/her own thing and tries to get other players to follow, but it needs to be explained to the whole team as to why that happened and explain the role of the coach and roles of the athletes"

Name Calling without Hurtful Intent

Comments in reference to this action are similar to those mentioned in poking fun at an athlete. Many coaches commented they did this but it was meant to be in fun, "Yes in jokes, it is a give and take" and "possibly in a playful/teasing manner". Others commented on the use of nicknames, "If your team culture is one where nicknames are okay, then this would be okay.", "We have team nick names from time to time. For example, a kid's name might be John David and we call him JD. Or a kid maybe is particularly skilled at hill running and we might call him the HB short for Hill Beast.", and "We have nicknames for everyone. So long as they are not offensive or hurtful." One coach commented, "Again, the types of names are critical in how they will be perceived, along with the tone, context, and body language. Calling a player, a "silly goose" is much more innocent and playful than a more demeaning remark"

Dirty Look Meant to Hurt an Athlete

One participant said, "I do not know what would constitute a "dirty look", but I have looked at athletes disapprovingly for inappropriate conduct on their part." Another said, "I've given frustrated looks when my athletes miss a sign or do something we have just talked about not doing. It was not meant to hurt an athlete but it very well could have hurt their feelings."

Discussion

Although the number of participants reporting to have done the listed actions appears low for most of the actions, the percentage of participants reporting to have done some of the actions is concerning. In particular, 'having thrown something at an athlete', 'embarrassing an athlete in front of others', 'dirty looks meant to hurt an athlete', 'poking fun at an athlete', and 'name calling without hurtful intent'. All five of these actions have been described as mild forms of bullying (Haber 2004), with one of them being physical and two each being relational and verbal.

When considering if an action is an inappropriate coaching action, three actions stand out: 'embarrassed an athlete in front of others', 'poking fun at an athlete', and 'name calling without hurtful intent'. As all three of these were identified as actions participants had done toward athletes, it makes sense that the participants would not consider them as inappropriate. Similarly, these three items were also indicated as not considered bullying by most of the participants.

For three of the five actions listed above, male participants reported having done so more than female participants. Two of these actions, 'embarrassed an athlete' and 'name calling', were more likely to be done by participants without college degrees and one of them, 'embarrassed an athlete', by a teacher. Although there were no differences in doing the actions, as based on years of experience, two significant differences noted by years of experience were identified when considering if an action is inappropriate and three differences when considering the action as bullying. In all five instances, participants with 30+ years of experience were less likely to consider the action as an inappropriate coaching action and as bullying.

When considering if one had ever done an action, only two differences were found based on level of earned degree. Participants without a degree were more likely to 'embarrass an athlete in front of others' and 'call someone a name with hurtful intent'. And finally, considering if one is a teacher or nonteacher, one difference was found in doing an action, that being 'embarrassed an athlete in front of others' with nonteachers doing it less than teachers and five differences in relation to considering an action as bulling.

Previous work on inappropriate coaching indicates great differences in the reporting of actions having been done by coaches, as reported by athletes (Strand et al. 2017). Using the same 22 actions as listed in this study, Strand et al. surveyed 920 college students on their perceptions of actions by their former coaches. As might be expected, athletes were more likely to report having had a coach do one the actions to them than a coach would self-report. For example, looking at the items mentioned as concerns earlier in this section, 16.1% of athletes compared to 9.8% of coaches reported having had 'something thrown at them' and 19.7% of athletes compared to 13.7% of coaches reported the 'coach used dirty looks meant to hurt'.

Two questions remain, first, are these actions inappropriate, and second, are they bullying. From a coaches' perspective, approximately three-fourths of coaches in this study indicated the actions were inappropriate, and approximately half indicated they considered the action as bullying.

Based on these findings, on one hand it is easy to understand how some coaches might be accused of inappropriate or abusive practices. If one does not think an action is inappropriate or bullying, there is no reason for a coach not to use that action when interacting with athletes. For many coaches, their coaching practices mirror that of coaches for whom they had previously played (Moen et al. 2015). Unfortunately for those coaches, what was once accepted as allowable is no longer accepted.

On the other hand, it is hard to understand how anyone coaching in today's society is not culturally or socially aware enough to recognize what is acceptable

and unacceptable. Is it perhaps that some coaches believe they have immunity for their actions because they are simply coaching and what happens during practice stays within the bounds of the practice field? As reported in Strand et al. (2017), coaches use any number of excuses to rationalize their actions including moral justification, backhanded apology, it could have been worse comparison, escalation of stakes, mental toughness argument, secrecy and building team culture.

The allegations filed against the basketball coach at Purdue-Fort Wayne included: the coach mocked players for depression, forced them to play through injuries, pressured them to go on medications, such as antidepressants, called them out of shape and fat, withheld medical care, denied them food as punishment, did not allow players to see a psychologist without a coaching staff present and once told a player to "get over it" after a sexual assault (Benbow 2021). The coach responded to the allegations with, "While I respect these women and their right to speak out, I deny that I have ever physically, mentally or emotionally abused any player in our program."

At Texas Tech, players accused their coaches of punishing players whose heart rates dropped below 90% of capacity during playing time for more than two minutes, of calling them "fat pigs' and "disgusting", of being mocked for weight and exhibiting signs of depression, and sexual harassment (Pao 2020). The coach responded with, "Our administration and my staff believe in the way we are building and turning this program around here. Our student athletes are developing a disciplined approach both on and off the court. I want our students, fans and alumni to know we are committed to winning championships at Texas Tech and doing it the right way through hard work, accountability and fierce determination."

The players at Detroit Mercy accused their coach of creating an environment "so toxic and draining that player's made comments in the locker room about having suicidal thoughts as well as purposely injuring themselves to avoid potentially having to deal the coaches' belittling and emotional abuse." (Solari 2021). Coach Gilbert responded with, "it completely blindsided me, in our opinion, we have a normal, healthy Division I atmosphere and environment". She further stated, "I came here to be a part of change, positive change, to help change the culture. To help chart a path to national prominence, to impact these women positively. I'm here to coach, to teach, to develop them and to grow them into strong, empowered women". Not surprisingly, all 14 players from the 2020-2021 roster either left the program or have been told they can no longer play basketball.

Obviously these three coaches fail to take responsibility for their actions and are in fact, justifying their means to an end. And in all reality, it does not really matter if a coach thinks his or her actions are appropriate or not and if those actions are considered bullying; if athletes perceive them to be such, they are.

Application

It is clear that not all coaches perceive and define inappropriate and bullying actions in the same way. It is therefore incumbent upon coaching education programs in colleges and universities, coaching associations (high school coaching

associations), and sport related organizations (NFHS) to more thoroughly help coaches understand which coaching practices are unacceptable and should not be used. Granted, some of these actions are difficult to interpret. For example, what is a dirty look meant to hurt? A coaches' glance at an athlete may be interpreted in different ways by different athletes, and certainly different from what a coach intended. Do we simply prevent this by telling coaches not to look at athletes? Of course, that is not the answer.

What it comes down to is awareness. Coaches must become aware that certain words and actions carry various meanings and are understood differently by different people. Further, coaches must make every effort to listen to their athletes and eliminate or redefine those actions that are blatantly inappropriate. For example, throwing something at an athlete. Just do not do that. Problem solved.

Conclusion and Further Study

From this study, researchers gained insight into coaches' use of what might be considered inappropriate coaching practices, their thoughts regarding if they believe an action is an inappropriate coaching action, and if they consider it bullying. Coaches and athletes certainly observe, feel, and value what they experience in different ways. A coach may look at an athlete in a certain way and think nothing of it while the athlete is interpreting the look as intentionally hurtful. A further study needs to determine if athletes think the listed actions are inappropriate and considered bullying with comparisons made to what coaches think.

Are there accepted different teaching/coaching behaviors from a classroom to a practice field or gym? Is it accepted that one can make critical comments meant to hurt someone in a sport setting but not in a classroom? Further research should investigate if coaches believe this difference exists and if it holds true.

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Sport and Cultural Events: Willingness to Pay, Facial Expressions and Skin Response

By Seppo Suominen[*]

The topic of this particular study is to combine facial expressions, skin response and willingness to pay (WTP) using an iMotions Platform. This software solution combines biosensors in human behaviour research. A useful method to estimate WTP is contingent valuation method (CV) (Mitchell and Carson 1989). The method has been widely used in cultural economics (Noonan 2003) and sport economics (Walker and Mondello 2007, Wicker et al. 2016a). CV method is made up of using surveys to elicit a willingness to pay for hypothetical changes in some good or service. Galvanic skin response (GSR), also known as electro dermal activity measures electrical activity conducted through sweat glands in the skin. It is an indication of the intensity of an emotion experienced (iMotions). GSR in an indication of stress (arousal of the sympathetic nervous system) in the body by appearing as continuous variation in the electrical characteristics of skin (De Brito and Mitchell 2019). Only joy and surprise are positively related to WTP, while the other emotions do no reveal anything. In addition, heart rate (GSR) and gender are significantly associated with WTP.

Keywords: *facial expressions, skin response, willingness to pay, sport events, cultural events*

Introduction

Setting the right price for a product or an event, like sporting event or cultural performance, is rather difficult for a marketer. The starting point in cost-based pricing is product, production costs, the price is set based on cost, and marketers need to convince buyers of product's value. The value-based pricing begins with access to customer need and value perceptions, after that the seller sets target price to match customer perceived value and the costs that can be incurred must be determined. Finally, the product should be designed to deliver desired value at target price (Armstrong and Kotler 2014). In value-based pricing customers set the maximum price, they are willing to pay for that event. Top cultural events are rather expensive, the ticket price for an opera performance varies from 35€ to 129€ (Don Giovanni, 7th March 2020, Helsinki Opera) depending on the seat at the opera, while a typical basketball game ticket is less expensive being about 15-28€ (Seagulls vs. Kouvot, 19th November 2019). We know that the spectators of opera and basketball are not the same (Suominen 2013). General belief is that high-income consumers favour cultural performances whereas high-income consumers do no typically attend sport events.

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Another topic, which is relevant in this particular study, is facial expressions and skin response. There is a wide literature in psychophysiological responses to music (Weth et al. 2015, Sutcliffe et al. 2017, Lynar et al. 2012). Among others, older adults were worse at detecting anger, sadness, fear, and happiness in music. The WTP is first investigated by paper and pen and then the respondents watch a video that contains different music performances and sport events. To the knowledge of the author, no such study of the relation between willingness to pay and biosensor data. The reason and motivation of the study is to explore the possible connections of artificial intelligence and willingness to pay in the sport context.

The topic "willingness to pay" has been widely investigated and there is a numerous literature, for example, the hits at Elsevier Science Direct is more than 55,000. WTP is related to incomes (Wicker 2011) and alternative or reference products. The maximum price (p_{max}) is the perceived preference price of the reference product (p_{ref}) plus the differentiation value between the reference product and the product of interest (p_{diff}): $p_{\max} = p_{ref} + p_{diff}$. Suppose you want to see a basketball game. The entrance ticket of the game is 25€. You have the option to see the game through the internet at a price of 20€ (reference product). However, seeing the game at the venue gives you aesthetic value which is not possible watching through the internet. If the differentiation value is equal or more than 20€, then you are willing to pay 25€. The economic value is the maximum price that a "smart spectator", fully informed about the market and seeking the best value, would pay. The economic value a person assigns to a product depends on the circumstances under which it is offered. The reservation price (p_{res}) is the highest price that a person will accept and still purchase the product. It is the price at which she is just indifferent between purchasing or not purchasing the product. The WTP is the highest price a person is willing to accept to pay for a product. If $p_{max} \leq p_{res}$ and the person purchases the product, the reservation price remains an unobservable variable because WTP is determined by the maximum price. If $p_{max} > p_{res}$ and the person purchases, willingness to pay is determined by the reservation price. The WTP depends on utility of the good and on the perceived economic value. If the consumer assumes that there is no alternative offering, the WTP equals the utility of the good and its reservation price. However, if the consumer perceives an alternative offering with economic value below utility, the highest price accepted is the economic value of the good and is the maximum price. The novelty of this particular research is to combine artificial intelligence and willingness to pay, and to the knowledge of author, this relation is new in research.

A useful method to estimate WTP is CV (Mitchell and Carson 1989). The method has been widely used in cultural economics (Noonan 2003) and sport economics (Walker and Mondello 2007, Wicker et al. 2016a). CV method is made up of using surveys to elicit a willingness to pay for hypothetical changes in some good or service. Respondents are asked to answer questions as to what actions they would take under a hypothetical event. Although the reliability and validity has been challenged, the method results in good predictions if the field of cultural

economics (Noonan 2003) and sport economics (Walker and Mondello 2007). CV method has been criticized since the hypothetical WTP may be a poor indicator of actual consumer responses or predictive validity. List and Gallet (List and Gallet 2001), however, find out that private goods generated less hypothetical bias than public goods.

CV has been widely used in the area of environmental cost-benefit analysis and economics (Venkatachalam 2004). The CV method was proposed in 1947 by Ciriacy-Wantrup (1947). He argued that the prevention of soil erosion generates extra market benefits that are public goods in nature. WTP was according to him one possible method to estimate these public benefits to elicit individuals' opinions. Davis (1963), however, was first to use CV empirically in estimating the benefits of goose hunting among goose-hunters through a survey. CV is suitable in welfare economics, where a monetary value is places on goods not actually exchanged in the market. Public goods, such as health, education and environmental quality can be measured using CV. In the context of sport and cultural performances, taxpayers' WTP for public subsidies has been measured using CV (Walton et al. 2008, Bille Hansen 1997). The respondent's age, gender and incomes have typically an impact on WTP. The literature on WTP in different sports contexts is extensive (Walker and Mondello 2007, Wicker 2011, Wicker et al. 2016b).

Galvanic skin response (GSR), also known as electro dermal activity measures electrical activity conducted through sweat glands in the skin. It is an indication of the intensity of an emotion experienced (iMotions). GSR in an indication of stress (arousal of the sympathetic nervous system) in the body by appearing as continuous variation in the electrical characteristics of skin (De Brito and Mitchell 2019). Increased skin conductance is associated with higher mental load and/or stress (Epps 2018). The measurement of emotional expression may include different physiological or neural parameters, such as galvanic skin response, heart rate, blood pressure, stomach contractions or dilation of blood vessels (Mainwaring 2011). In the sport context, GSR is common, however mainly in coaching and sport science. High impact sport exercising is related to heart rate level and heart rate variability (Tulppo et al. 1998). GSR in relation to music has been studied somewhat (Berger and Turow 2011).

Facial expression analysis uses webcam to synchronize expressed facial emotions with stimuli directly using a software. An important standard for measuring emotional facial expressions is the Facial Action Coding System (FACS) by Ekman and Friesen (1976). Automated facial expression analysis uses several observable action units that account for facial expressions and in turn for the expression of emotions. The iMotions platform and software classifies emotions into seven categorical emotions: joy, anger, surprise, fear, contempt, sadness and disgust.

A recent review article by Teal et al. (2019) shows that emotions have an important component in pertaining sport sponsorship. Emotions have an impact on intentions and purchasing behaviour. Facial expressions are generated by contractions of facial muscles, which results in facial features such as eyelids and eyebrows, nose, lips and skin texture (Fasel and Luettin 2003). The muscular

activities changes are brief, usually less than 5 s but more than 250 ms. Facial expression intensities can be measured by determining the geometric deformation of facial features or the density of wrinkles appearing in certain face regions. The iMotions platform algorithm, Affective AFFDEX uses head orientation (yaw, pitch, roll), interocular distance and 34 facial landmarks and based on these the algorithm classifies seven categorical emotions mentioned above and besides these also valence, engagement and attention. 14 facial expression metrics are calculated.

Soccer teams with displaying both anger and happiness were positively correlated with team performance in the World Cup. Teams with more anger, emotion associated with competitiveness, concede less goals and teams with more happiness, emotion associated with confidence, score more goals (Hopfensitz and Mantilla 2019). However, the results should not be interpreted as teams whose players are angrier or happier perform better since the reverse might be more plausible: performing better leads to angrier or happier faces.

Methodology

Consider a simple case in which the consumer's purchases are limited to two commodities. Her ordinal utility function is $U = f(q_1, q_2)$. A rational consumer wishes to purchase a combination of q_1 and q_2 from which she derives the highest level of satisfaction. Her income y^0 is limited and the budget constraint is $y^0 = p_1 q_1 + p_2 q_2$. The consumer desires to maximize utility subject to budget constraint. The first order condition for a maximum is expressed by the equality of rate of commodity substitution and the price ratio: $\frac{f_1}{f_2} = \frac{p_1}{p_2}$. Marginal utility divided by price must be same for all commodities.

Due to data collection method we assume that willingness to pay is related to emotional expression measured by galvanic skin response and facial expression. The data collection uses both iMotion platform and algorithms and we assume that emotional expression measures marginal utility. Before measuring emotional expression, the respondents are asked to fill a questionnaire that includes few questions concerning willingness to pay.

Students of Haaga-Helia University of Applied Sciences first fill in a questionnaire shown in Table 1:

How much would you be at most ready to pay for the events mentioned below?

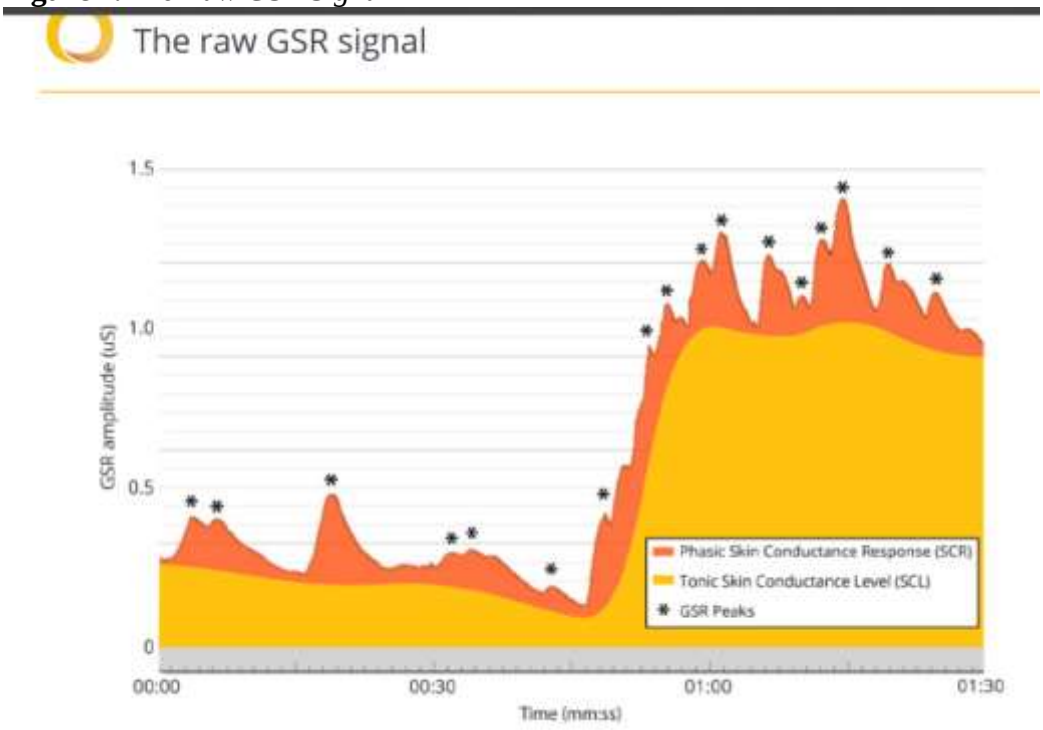
Table 1. *Questionnaire*

	Jazz music concert	Aesthetic Group gymnastics	Ice Hockey	Classical music concert	Athletics	Rock music concert
0, not interested						
5€						
10€						
15€						
20€						
25€						
30€						
35€						
40€						
45€						
50€						
More than 50€, how much?						

After having filled the questionnaire, the students watch a video that contains eight different parts, each lasting about one minute. The first is Pekka Pohjola's "First morning" a classical fusion jazz piece of music. Despite that, the album where First morning is included was chosen as the best album of the year by national broadcasting company Yleisradio, probably the students in sample have not heard it before. However, it was not asked. There was no visual content in the video except the album sleeve. The second video clip contains aesthetic group gymnastics, the performance of Minetit, which was the Finnish champion in 2019. The performances in aesthetic group gymnastics are very beautiful but difficult. Most Finns do not know the sports. Based on the author's opinion the audience in aesthetic group gymnastics competitions is made up of solely persons who are relatives of the gymnasts or who are exercise gymnastics themselves. The third video clip contains some moments of the crucial ice hockey game where two Finnish teams, HPK (located in Hämeenlinna) and Tappara (Tampere) were competing on purpose to be the champion of the season 2018-2019. Usually Tappara is considered stronger since it has more financial resources and a better recent record in ice hockey, however, HPK won the game. The fourth video clip is classical music, Karelia by Sibelius. The only visual content is merely a birch forest view with no dynamics. The music was composed in 1893 and well known throughout the whole Finland. The fifth clip contains a pole vault attempt by a female Finn, Minna Nikkanen. She actually passed the bar at the height of 456 cm, which was its time in 2015 the Finnish record. The sixth clip contains punk rock or alternative rock music "Rappiolla" by Hassisen kone. The hit was published in 1980 and it is very popular still today. The video clip contains only black record and no dynamic visual content. The seventh video clip contains a famous music by Lasse Mårtensson: "Myrskyluodon Maija". In the 1970's a television series with the same name was broadcasted. The music in the series was published in 1977. The video clip contains first symphony orchestra version of the music and soprano

Karita Mattila singing but during the clip, the performance totally changes to Apocalyptica, which is a Finnish symphonic metal band. The last video clip contains the last minute of the 5000 m Olympic competition in 1972 at München, Germany where a Finn, Lasse Viren won the competition. The overall length of the video is about 8 min and 22 sec.

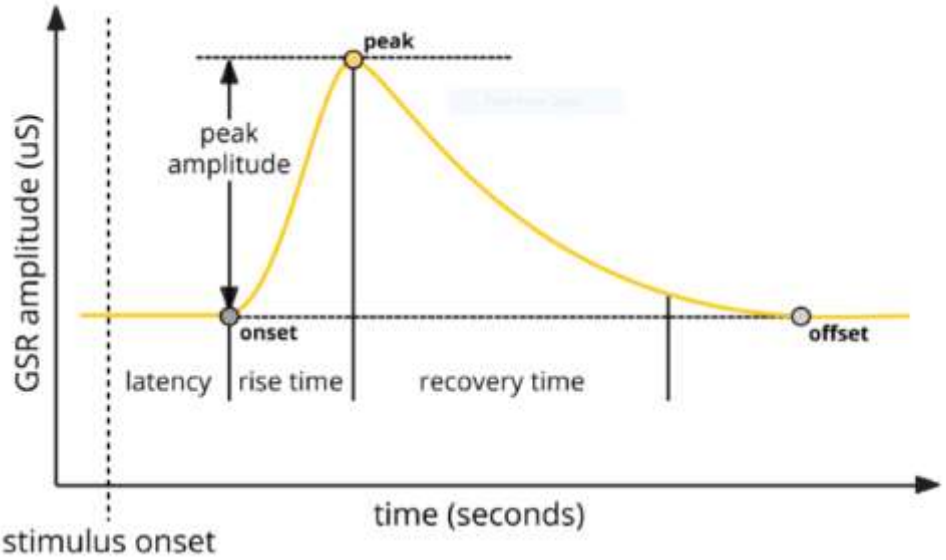
Figure 1. *The Raw GSR Signal*



The iMotions platform uses artificial intelligence and classifies facial expression into seven categorical emotions: joy, anger, surprise, fear, contempt, sadness and disgust. The algorithm uses automated facial coding engine called AFFDEX. The facial action coding system (FACS) refers to a set of facial muscle movements that correspond to a displayed emotion (iMotions). Using the system, we are able to determine the displayed emotion of the participant. Affectiva AFFDEX monitors head orientation (yaw, pitch, roll), interocular distance and 34 facial landmarks. The other module of the platform is GSR. The logic behind GSR is simple: place two electrodes on emotionally sensitive body locations, apply a constant low voltage, measure the electrical current between the two electrodes and get the associated skin conductance. The palms of the hands, fingers and foot soles are sensitive recording sites. GSR activity is typically measured in micro-Siemens (μS) (Figure 1).

The original GSR signal can be decomposed into a) duration from stimulus, b) peak amplitude, 3) rise time and 4) recovery time (Figure 2).

Figure 2. *GSR Signal Decomposition*



In this particular study, the sites are fingers but only the heartbeat level is used individually in each eight video clip, since in emotional situations bodily processes are triggered automatically: the heart beats faster, the pulse rises and hands become sweaty.

The iMotions Platform is a commercial product. Based on two rather large validation studies (Stöckli et al. 2018) iMotions has potential to measure basic emotions expressed by faces, however, it has problems to distinguish expressions of fear and surprise.

Results

Due to strict regulations of collecting personal and very sensitive data, the study was able to collect only ten participants' data. They are all studying business at Haaga-Helia University of Applied Sciences. It was not possible to command any person to participate. The first step to analyze the results was to estimate the averages of each emotion and heart rate during each video clip. Some descriptive statistics are presented in Table 2.

Since some emotions are highly positively correlated, each emotion is used individually in relation to each WTP. Willingness to pay is studied in relation to corresponding video clip. The first clip contains jazz music and the corresponding willingness to pay for a jazz music concert is related in the regression analysis. The second willingness to pay question addresses aesthetic group gymnastics and the second video clip contains gymnastics, so each emotion in watching gymnastics are incorporated with this WTP question. The links are shown in Table 3.

Table 1. *Descripive Statistics of Emotions and Heart Rate of Each Individual n = 10*

n = 10		**correlation**						
	mean	**contempt**	**disgust**	**fear**	**joy**	**sadness**	**surprise**	**heart rate**
anger	0.839	0.491	0.714	-0.076	-0.074	0.813	-0.042	0.072
contempt	0.303		0.313	-0.071	-0.123	0.450	-0.038	0.068
disgust	0.441			-0.042	-0.348	0.466	0.111	-0.067
fear	2.482				0.005	-0.107	0.314	-0.123
joy	3.513					-0.094	-0.014	-0.024
sadness	1.123						-0.056	0.146
surprise	1.107							-0.138
heart rate	83.842							

Table 3. *Relations between Willingness to Pay and the Video (or Audio) Clip*

WTP: avg, (std)	**video clip**
jazz music concert 34.5 (26.8)	← Pekka Pohjola (only audio)
aesthetic group gymnastics 18.5 (14.1)	← Minetit (visual and audio)
Ice hockey 61 (47.7)	← HPK vs. Tappara (vis. & aud.)
classical music concert 38.5 (42.6)	← Sibelius (only audio)
classical music concert 38.5 (42.6)	← Myrskyluodon Maija (vis & aud)
Athletics 26 (20.5)	← Minna Nikkanen (vis & aud)
Athletics 26 (20.5)	← Lasse Viren (vis. & aud)
Rock music concert 81 (59.1)	← Rappiolla (only audio)

The regression analysis results on the relation between willingness to pay and different emotions are shown in Table 4. Gender and the age of the respondent are the controlling variables. Women seem to be willing to pay more and heart rate is positively related to willingness to pay. Not all emotions are related to willingness to pay, however, in Table 4 where only the audiovisual clips are used, joy and surprise are positively related to willingness to pay. Tentatively it also seems that age is negatively related to WTP. Age is measured by days, the magnitude is less than -2 €/per year. Despite the fact, the sample is very small; attitude of women to pay more is in line with previous studies (Wicker et al. 2016b).

Table 4. *Regression Analysis -Willingness to Pay in Relation to Gender, Age, Heart Rate and Emotions (Separately), Both Audiovisual and Only Audio Clips*

n = 80	**audiovisual (5 clips) and only sound (3) clips**													
woman	31.232***	43.261***	31.337***	42.724***	33.418***	43.211***	33.133***	41.127***	29.303***	37.155***	30.015***	40.694**	34.133***	41.062***
	(9.066)	(11.957)	(8.935)	(11.383)	(8.807)	(10.367)	(8.736)	(10.139)	(8.875)	(10.434)	(9.032)	(12.633)	(8.844)	(10.142)
age		-0.005		-0.005		-0.005		-0.004		-0.004		-0.004		-0.004
		(0.003)		(0.003)		(0.002)		(0.002)		(0.002)		(0.003)		(0.003)
heart rate	0.497*	0.571**	0.497*	0.569**	0.508**	0.589**	0.480*	0.547**	0.487*	0.548*	0.512**	0.562**	0.528**	0.576**
	(0.193)	(0.197)	(0.193)	(0.197)	(0.193)	(0.196)	(0.193)	(0.197)	(0.190)	(0.194)	(0.193)	(0.196)	(0.195)	(0.197)
	anger		contempt		disgust		fear		joy		sadness		surprise	
emotion	-0.668	0.585	-3.415	3.250	13.085	19.510	-0.425	-0.364	0.540	0.477	-1.300	-0.033	0.677	0.426
	(1.303)	(1.531)	(7.867)	(8.909)	(19.450)	(19.553)	(0.564)	(0.560)	(0.365)	(0.365)	(1.310)	(1.676)	(0.713)	(0.732)
constant	-19.351	27.489	-19.168	26.100	-27.948	16.115	-18.612	22.338	-19.887	18.169	-19.051	21.540	-25.028	15.046
	(18.636)	(35.839)	(18.771)	(34.696)	(21.488)	(33.099)	(18.630)	(32.710	(18.264)	(32.558)	(18.463)	(38.382)	(19.004)	(34.805)
R^2	0.155	0.170	0.154	0.169	0.157	0.179	0.158	0.173	0.176	0.186	0.163	0.168	0.162	0.172
F	5.85**	5.05**	5.82**	5.05**	5.93**	5.32***	5.98***	5.14***	6.64***	5.54***	6.15***	5.00**	6.11***	5.11**
χ^2	16.63***	19.07***	16.55***	19.06***	16.83***	19.97***	16.95***	19.37***	18.63***	20.72***	17.36***	18.92***	17.30***	19.28***

Table 5. *Regression Analysis - Willingness to Pay in Relation to Gender, Age, Heart Rate and Emotions (Separately), Only Audiovisual Clips*

n = 50	**only if the video clip contains live visual content**													
woman	29.309**	43.718***	28.128**	44.521***	30.369**	41.754***	31.524***	41.893***	24.748**	34.447***	29.186**	51.297***	24.274**	30.438**
	(9.175)	(11.315)	(9.165)	(12.591)	(9.003)	(10.440)	(8.953)	(10.082)	(8.254)	(9.439)	(9.384)	(12.933)	(7.747)	(9.370)
age		-0.006*		-0.007(*)		-0.006*		-0.005*		-0.005		-0.009*		-0.003
		(0.003)		(0.003)		(0.003)		(0.002)		(0.002)		(0.003)		(0.002)
heart rate	0.573*	0.663**	0.582**	0.663**	0.566**	0.656**	0.560**	0.643**	0.546**	0.617**	0.577**	0.681**	0.628***	0.665***
	(0.200)	(0.199)	(0.199)	(0.199)	(0.201)	(0.199)	(0.200)	(0.198)	(0.181)	(0.180)	(0.201)	(0.196)	(0.171)	(0.174)
	anger		contempt		disgust		fear		joy		sadness		surprise	
emotion	-0.713	0.527	-17.487	8.596	-7.790	1.296	-0.507	-0.370	1.047**	0.980**	-0.624	1.927	62.163***	56.763***
	(1.219)	(1.328)	(17.143)	(21.877)	(17.550)	(17.560)	(0.643)	(0.627)	(0.321)	(0.313)	(1.289)	(1.635)	(14.809)	(15.471)
constant	-31.391	28.718	-27.627	30.646	-28.369	23.912	-31.043	23.576	-30.325	17.908	-31.527	48.200	-51.860**	-21.079
	(9.370)	(34.967)	(19.735)	(36.948)	(21.616)	(33.145)	(19.297)	(32.928)	(17.420)	(30.020)	(19.416)	(38.430)	(17.040)	(31.498)
R^2	0.222	0.272	0.233	0.272	0.219	0.269	0.226	0.275	0.363	0.399	0.220	0.291	0.433	0.437
F	5.67**	5.58***	5.99**	5.58***	5.60**	5.52**	5.80**	5.65***	10.32***	9.16***	5.62**	6.04***	13.50***	10.54***
χ^2	15.73***	20.14***	16.48***	20.13***	15.57***	19.97***	16.03***	20.35***	25.74***	29.78***	15.61**	21.48***	31.57***	33.05***

Table 6. *Regression Analysis - Willingness to Pay in Relation to Gender, Age, Heart Rate and Emotions (Separately), Only Music Clip without Visual Content, except the Two Last Columns*

n = 30	**only if the video clip does not contain live visual content**														**n = 40, only music**	
woman	34.539 (19.539)	40.833 (30.910)	34.649 (18.500)	38.151 (25.031)	42.938* (17.080)	47.533* (20.435)	36.419(*) (8.953)	40.159(*) (21.502)	41.235* (18.508)	47.271* (22.432)	32.398(*) (18.086)	28.783 (24.750)	38.635(*) (7.747)	40.410(*) (21.600)	39.653** (14.047)	44.243* (16.662)
age		-0.002 (0.009)		-0.001 (0.007)		-0.002 (0.005)		-0.002 (0.006)		-0.003 (0.006)		0.001 (0.007)		-0.001 (0.006)		-0.002 (0.004)
heart rate	0.413 (0.388)	0.447 (0.414)	0.412 (0.387)	0.436 (0.410)	0.533 (0.366)	0.574 (0.384)	0.387 (0.389)	0.421 (0.409)	0.407 (0.381)	0.457 (0.399)	0.471 (0.287)	0.455 (0.401)	0.456 (0.403)	0.467 (0.414)	0.574(*) (0.299)	0.611(*) (0.310)
emotion	anger		contempt		disgust		fear		joy		sadness		surprise		disgust	
	-0.719 (3.267)	0.201 (4.832)	-3.279 (10.845)	-1.805 (13.046)	103.591(*) (52.067)	104.313(*) (52.934)	-0.434 (1.007)	-0.425 (1.025)	-0.796 (0.850)	-0.862 (0.873)	-2.724 (2.921)	-3.177 (3.625)	0.397 (0.963)	0.313 (1.082)	97.875* (46.136)	97.983* (46.607)
constant	-3.053 (37.403)	17.107 (85.669)	-3.279 (10.845)	11.056 (73.840)	-63.935 (45.699)	-41.768 (69.745)	-1.470 (37.461)	17.088 (68.245)	-4.099 (36.411)	23.749 (67.579)	-4.328 (36.416)	-19.287 (77.786)	-10.732 (40.070)	2.219 (81.113)	-66.072 (38.162)	-42.908 (58.554)
R^2	0.04	0.01	0.05	0.01	0.173	0.146	0.05	0.02	0.174	0.182	0.07	0.04	0.05	0.01	0.189	0.172
F	1.50	1.10	1.52	1.11	3.03*	2.25(*)	1.56	1.15	1.83	1.39	1.82	1.33	1.55	1.13	4.03*	3.03*
χ^2	4.80	4.88	4.85	4.90	9.00*	9.21(*)	4.96	5.09	5.74	6.03	5.73	5.79	4.94	4.98	11.59**	11.90*

Results is Table 5 indicate that only with audiovisual element, the facial recognition and galvanic skin analysis with iMotion Platform seem to reveal plausible observations. Only joy and surprise are positively related to WTP, while the other emotions do no reveal anything. Based on validation of the AFFDEX algorithm, it has relatively poor accuracy in fear and anger (Stöckli et al. 2018), therefore it is possible that we find no evidence on the relation between WTP and fear and anger. Without visual content in Table 6 the results suggest that any emotion is not related to WTP except disgust, which is astonishing. Since we have only music recordings in the last subsample without visual content, the disgust or antipathy in relation to music genre is positively related with WTP. This result must be interpreted with caution since the sample size is very small.

The results suggest that dynamic visual content is important in connecting willingness to pay and facial recognition, a still figure without any dynamic visual content does not give enough signals so that we could significantly relate facial recognition and subjective prior wishes.

Summary and Conclusion

The purpose of this study was to combine artificial intelligence and willingness to pay. First, the respondents were asked to fill a questionnaire. The questions were all in the field of sport and cultural events. In the second phase, they watched a video with eight different sport or music events or music recordings, the length of these were about one minute each. The overall length of the video clips was a bit longer than eight minutes. The results indicate that a dynamic visual content is important. A static figure, like disc cover is not enough, the artificial intelligence is not able to distinguish emotions and combine these with subjective prior wishes on the willingness to pay. The sample size is very small and the iMotion platform is a commercial product not designed for scientific research, however, some interesting results arose. Willingness to pay is positively related to joy and surprise, which is reasonable.

The study reveals that it is possible to combine artificial intelligence, human behaviour and willingness to pay in the sporting or cultural events context. This result is important since with these machine tools we might see in the future a situation in which the machine dynamically changes the price according to the motions that artificial intelligence is able to reveal. If the person in a purchasing situation shows interest towards a good or service and artificial intelligence is able to recognize this interest, then the machine proposes a higher price. Machines might take a role in the price negotiating process.

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Selective Androgen Receptor Modulators (SARMs) in Sports: A Review

By Veselin Vasilev[*] & Nikolay Boyadjiev[±]

Selective androgen receptor modulators (SARMs) are an exciting group of molecules with pronounced anabolic effects and very weak to missing androgenic ones. This is due to the tissue selectivity they possess and is their big advantage over anabolic androgenic steroids (AAS). As a result of this SARMs tend to be a big promise for improving the treatment process in different socially significant diseases such as osteoporosis, muscle wasting, benign prostatic hyperplasia, hypogonadism, sexual dysfunction, neurodegenerative diseases etc. SARMs are included in the prohibited list of World Anti-Doping agency (WADA) as they are a temptation for a lot of athletes regarding the exerted strong anabolic effect. However, as SARMs are freely available on the internet there are some reports for positive doping tests in professional sports connected with them. Still further research is needed to examine all the side effects of SARMs. Some of them may be harmful so both professional and amateur sportsmen, their coaches and doctors should be informed about this interesting topic.

Keywords: *SARM(s), anabolic effect, sports, doping, side effects*

Introduction

A very popular group of substances appropriate for misuse in sports are the anabolic androgenic steroids (AAS). AAS bind to the androgen receptor and perform strong anabolic effect due to which they increase the muscle mass and strength. Even though this can be an advantage in sports at the same time they pose risks concerning the health of their users. AAS have a strong androgenic effect which leads to a lot of side effects. In the last decades a number of side effects were described, some of them were irreversible. AAS increase the risk of severe myocardial damage, liver injury, testicular atrophy, menstrual disorders, hirsutism, psychological disorders, hematological alterations, clitoral hypertrophy, voice deepening and many others. At the end of the previous century a new class of molecules was discovered; the non-steroidal selective androgen receptor modulators (SARMs). They represent a new class of androgen receptor ligands that act similarly to anabolic steroids, but are selective in their effects, with anabolic predominance, and androgenic ones being relatively limited. This gives a number of advantages of SARMs over the anabolic androgenic steroids, associated with avoiding some of the side effects of the latter. Therefore, they can have a big impact on patients with a number of socially significant diseases, such as osteoporosis, benign prostatic hyperplasia, sarcopenia, neurodegenerative diseases

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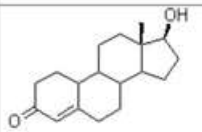
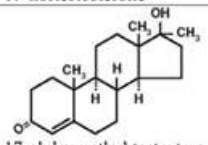
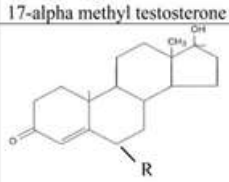
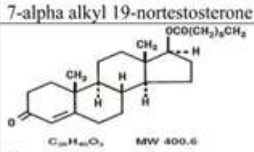
(Alzheimer's disease), sexual dysfunction, breast cancer, sarcopenia, various types of cachexia and hypogonadism (Chen et al. 2005a, Zhang and Sui 2013).

The selective androgen receptor modulators are commonly used in different sports to boost the physical performance and to increase athletic achievements due to the strong anabolic and weak androgenic effects. However, since 2008, they have been included in the list of prohibited substances of WADA, falling under the category of "other anabolic agents" in Section S1.2 of this list (Thevis and Schaenzer 2018). Even though there is currently no approved representative of SARMs as a drug by Food and Drug Administration (FDA), the substances are freely available on the internet. There is an evidence provided by the study of Van Wagoner et al. (2017) that only 52% of the 44 products offered online and tested contained real SARMs (Van Wagoner et al. 2017). There is a possibility the concentration of SARMs in the product to be different from the expected one, usually lower. Moreover, SARMs can be included as ingredients in different dietary supplements which poses a significant risk of giving a positive test during doping control in sports. In some cases, as a matter of fact, consumers can be tricked by masking the presence of SARMs on the label, using a coded one instead of the trade name of the representative (for example, MK-2866 or GTx-024 is indicated as an ingredient, instead of Ostarine). More control is needed on the trade with these substances on the internet and most importantly regarding the dosage. Very often the recommended dose is times higher than the effective one in clinical trials. Andarine and Ostarine are the most commonly used preparations from this group (Geyer et al. 2014). Various screening methods such as gas chromatography, liquid chromatography or mass spectrometry can be used during doping-control in sports to prove the misuse of SARMs. The presence of their metabolites can be easily detected in blood or urine specimens (Thevis et al. 2008a, Thevis et al. 2008b, Thevis et al. 2011). This leads to an increasing number of positive doping tests in professional athletes.

With regard to their chemical structure, SARMs can be divided into two main groups: steroidal and non-steroidal. The steroidal group of SARMs representatives were known as early as the middle of the last century (Bhasin and Jasuja 2009). The steroidal types of SARMs were obtained through structural changes in the molecule of testosterone. By removing the 19-methyl group, an increased anabolic effect of testosterone was achieved. Replacement of 7-alpha alkyl group reduced the interaction with the enzyme 5-α reductase and increased its tissue selectivity. Replacing the 17-alpha alkyl group increased the half-life of testosterone. The first non-steroidal SARMs were presented in 1998 and since then there has been a growing list of substances of this group, some of which are drug candidates and some of them are currently under clinical trials (Chen et al. 2005a). Non-steroidal SARMs are grouped into different classes: aryl propionamide analogues, bicyclic hydantoin analogues, quinolones, tetrahydroquinoline analogues, butanamides, benzimidazoles, tropanol derivatives, indole derivatives, thiophene derivatives and many others. The first discovered class was that of aryl propionamides. The number of representatives of the different classes is constantly increasing (Temerdashev and Dmitrieva 2020). Narayanan et al. (2008), Bhasin and Jasuja (2009) and Jasuja et al. (2012) represent very adequately the chemical structure of

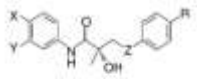
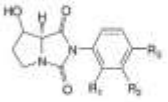
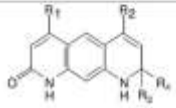
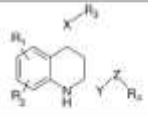
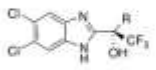
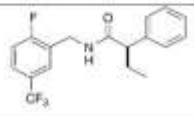
the two main groups of SARMs (Bhasin and Jasuja 2009, Jasuja et al. 2012, Narayanan et al. 2008) (see Tables 1 and 2).

Table 1. *Steroidal SARMs Structure*

Structure:Activity Relationship	Compounds	Chemical Structure
Removing 19 methyl increases anabolic activity	19-nor testosterone (nandrolone) series of compounds	 19-nortestosterone
17-alpha alkyl substitutions retard first-pass presystemic metabolism	Many orally active steroidal androgens have 17-alpha alkyl substitutions	 17-alpha methyl testosterone
7-alpha alkyl substitutions increase anabolic activity	7-alpha-methyl-19-nortestosterone	 7-alpha alkyl 19-nortestosterone
Esterification of 17-beta hydroxyl group increases hydrophobicity and extends duration of in vivo action	Testosterone enanthate, cypionate, and undecanoate	 Testosterone enanthate

Source: Bhasin and Jasuja 2009, Jasuja et al. 2012, Narayanan et al. 2008.

Table 2. *Non-Steroidal SARMs Structure*

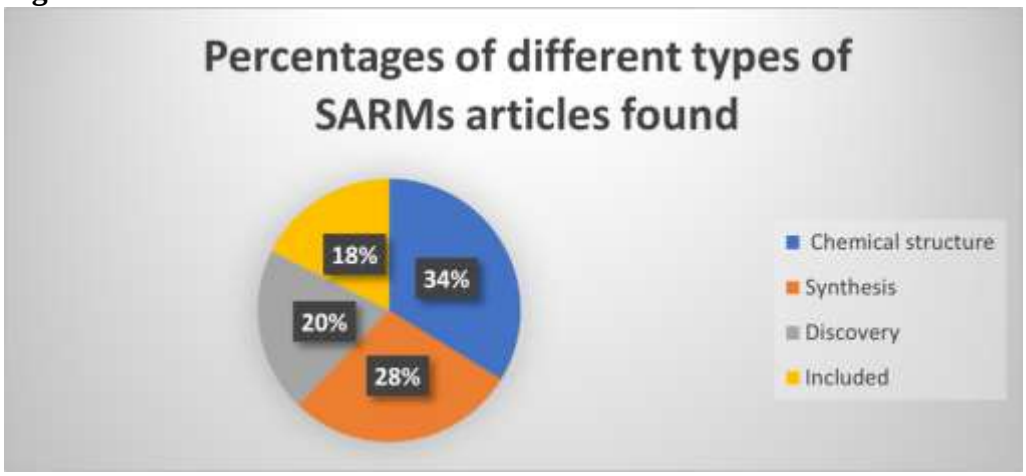
Chemotype	Structure	Examples
Aryl-propionamide analogs		Ostarine, andarine
Bicyclic hydantoin analogs		BMS-564929
Quinolinones		LGD-2226, LGD-2941
Tetrahydroquinoline analogs		Kaneh Pharmaceuticals, S-40503
Benzimidazoles		Johnson and Johnson's benzimadozole derivative
Butanamides		Merck SARM based on butanamide scaffold

Source: Bhasin and Jasuja 2009, Jasuja et al. 2012, Narayanan et al. 2008.

Materials and Methods

To be able to write this review we used different electronic databases such as Elsevier, Google Scholar, Science Direct, PubMed, etc. The main purpose of our article is to make sports professionals familiar with the presence of SARMs on the market and to increase their knowledge regarding the mechanism of action, usage of this group of substances, their potential risks and benefits and with the latest data concerning the doping control. In the literature we managed to find over 350 articles in English for the period between 1998-2021 years. There were some studies which were in different from English language, so we did not include them in our review. The terms we typed in the databases were 'selective androgen receptor modulators', 'SARM(s) and exercise', 'selective androgen receptor modulators rats', 'ostarine', 'ligandrol' 'SARMs doping', 'SARMs positive doping tests', 'SARMs rats'. The review is based on 60 articles. All the articles included were freely available for us. The main reason for an article not to be included in our review is that it does not provide the type of information we were looking for. For example, it gives detailed explanation about the chemical structure and development of SARMs and the process of their synthesis and discovery. As we already said this is not the focus of our review and such articles were considered irrelevant by us. The articles selection is presented in Figure 1.

Figure 1. *Articles Selection*



Results

Mechanism of Action

In order to exert their effects SARMs have to bind to the androgen receptor (AR) by genomic mechanism. AR is coded by a gene that is located on the X chromosome (Narayanan et al. 2018). AR is a transcription factor and consists of different domains. AR is located in the cytoplasm of the cell as its ligands are liposoluble and can pass through the cellular membrane. After the ligand binds to the receptor, initially, conformational changes in the receptor occur. The hormone-

receptor complex is formed and it moves to the cell nucleus. There, an interaction with the nuclear DNA will take place. Thus, AR may activate target genes that are involved in the regulation of various physiological processes. However, very important for its transcriptional activity is the group of proteins known as co-regulators. They are divided into two subgroups: co-activators which increase the transcriptional activity, and co-repressors which will decrease it. When DHT, testosterone or AAS bind to AR, the induced conformational change of the receptor leads to interaction with some co-regulators, and when SARMs bind to AR, the conformational change and co-activators with which AR interacts, are others (Narayanan et al. 2008, Narayanan et al. 2018). More than 200 co-regulators are known to activate or suppress various target genes. Other SARMs which can perform their effects by non-genomic mechanism also exist. Such representative is YK11. The mechanisms by which tissue selectivity of SARMs is achieved are not fully understood, but there are different hypotheses. Testosterone and anabolic androgenic steroids (AAS), under the action of the enzyme 5-α reductase, are converted into dihydrotestosterone (DHT) and other metabolites, which have greater biological activity and more pronounced effects on the genitals. In contrast SARMs are not susceptible to the action of this enzyme which helps to demonstrate their tissue selectivity (Gao et al. 2004). Another enzyme whose action is associated with side effects when taking AAS or testosterone is aromatase. It converts androgens into female sex hormones (estrogens), which are also responsible for the abovementioned side effects. Non-steroidal representatives of SARMs are not susceptible to the action of this enzyme as well (Bhasin 2015).

After binding to AR, DHT and SARMs increase the phosphorylating activity of various kinases (Bhasin and Jasuja 2009). Typically, a non-steroidal SARMs representative of the aryl propionamide class will mediate its effects through the following kinase pathways: MEK, ERK, p38 MAPK and others. While DHT uses the kinase pathways: PI3K, PKC, ERK and others (Narayanan et al. 2008). This shows that the two groups of ligands use different signaling pathways. The conformational change caused by the classical agonists of AR (testosterone or AAS) favours the classical intramolecular N-terminal/C-terminal interaction (N/C interaction). This interaction is essential for the selection of certain co-regulators, for the transcriptional activity of AR and for the modulation of target genes. In the synthesis of SARMs, the aim is to bring about a conformational change which does not stimulate this N-terminal/C-terminal interaction (N/C interaction).

Important Effects of SARMs

Effects on Bones

SARMs exert positive effects on bone tissue and its metabolism which is important for all sports. For example, Ostarine helped the formation of bone callus and healing of the bone after osteotomy. It increased the concentration of serum alkaline phosphatase, raised the serum level of phosphorus, and reduced the serum cholesterol level (Komrakova et al. 2020). Unlike Ostarine, the commonly used anabolic-androgenic steroid nandrolone decanoate induced femoral fracture in rats after an intake of twenty-seven days, stimulated to a less extent the formation of

callus and had no effect on the intact part of the bone (Guimarães et al. 2017). On the other hand, the selective androgen receptor modulator S-4 reduced the expected loss of bone substance in an osteoporosis model in rats maintaining bone mineral density and enhancing bone strength (Kearbey et al. 2007). In another study, in an osteopenic model in female rats, it was found that taking S-4 for 120 days after the ninetieth day following ovariectomy resulted in almost complete restoration of bone parameters compared to those of intact rats. Contrary to bone resorption, which was suppressed, bone anabolism was stimulated (Kearbey et al. 2009). Another modulator i.e., JNJ-28330835, also suppressed bone resorption (Allan et al. 2007). Again, in a model of osteoporosis in rats, the representative of tetrahydroquinolone analogues S-40503, after an intake of 4 weeks, led to an increase in the bone mineral density of the femur and the deposition of minerals in the periosteum of the same bone (Zhang and Sui 2013). This indicates the direct stimulating effect on bone formation of this SARM molecule (Hanada et al. 2003). The representative YK11 was able to stimulate the proliferation of MC3T3-E1 osteoblast cells in mice. YK11 also caused a significant increase in the specific markers for osteoblast differentiation osteoprotegerin (an inhibitor of osteoclastogenesis) and osteocalcin in comparison with the markers in untreated cells (Yatsu et al. 2018).

The combined application of the selective androgen receptor modulator LGD-3304 with a representative of bisphosphonates (alendronate) led to the potentiation of the effects of both substances and obtained a better total effect which is suitable for the treatment of osteoporosis (Vajda et al. 2009). S-101479 enhanced the activity of the alkaline phosphatase, the transcriptional activity of the androgen receptors in the osteoblast cell line and increased the bone mineral density without stimulating the proliferation of the endometrium in an osteopenic model in female rats (Furuya et al. 2013). Another study, once again in an osteopenic model in rats, compared the effects of S-101479 with other drugs for treatment of osteoporosis: bisphosphonates, selective estrogen receptor modulators (SERMs) and synthetic analogues of parathyroid hormone. All substances increased the bone mineral density. Only S-101479 increased the size of the bone. Potentiation of their effects was observed in combined application (Furuya et al. 2012). The preparation 4c had an osteoanabolic effect in female rats with induced osteoporosis and had a sparing effect on uterus compared with DHT (Nagata et al. 2011). Another representative of SARMs, i.e., 1d, also used in a model of osteoporosis in female rats, increased the bone mineral density of the femur, without any side effects on the uterus and the clitoris (Nagata et al. 2014). LGD2226 is also a non-steroidal representative of SARMs, which prevented a decrease in bone density, suppressed the bone resorption and stimulated bone formation in an osteopenic model in rats (Rosen and Negro-Vilar 2002). Some of the carboranes which are carbon-containing compounds, derivatives of the chemical element boron, may have effects on bone tissue such as those of SARMs. It was found that the representative of this group, BA321, restored the lost bone density in castrated male and female rats. In male rats, it increased the weight of the seminal vesicles, and in females reduced the induced atrophy of the uterus (Watanabe et al. 2016).

Effects on Muscles

SARMs also have a number of pronounced beneficial effects on muscle tissue what ranks them among the candidates for the treatment of cachexia and sarcopenia of various origin and for misuse in sports as well. In the literature there are several effects of YK11. For example, it activated AR without performing the N/C-terminal interaction, induced the differentiation of the C2C12 myoblast cell line. DHT demonstrated the same effect, but YK11 more effectively induced the key myogenic regulatory factors (myogenic differentiation factor, myogenic factor 5, and myogenin). YK11 also stimulated the expression of follistatin, which plays a major role in the realization of YK11-mediated myogenic differentiation (Kanno et al. 2013). The JNJ28330835 modulator, alternately, reduced by half the loss of lean body mass caused by orchidectomy in rats. It also mediated the restoration of 30% of the already lost muscle body mass in older castrated rats and stimulated the growth of m. levator ani (Allan et al. 2007). JNJ 37654032 is a similar agent with identical effects (Allan et al. 2008), and the MK-4541 modulator preserved lean body mass in female rats after ovariectomy (Chisamore et al. 2016). The administration of glucocorticoids or hypogonadism can cause muscle atrophy in rats, but the disease may be favourably affected by the intake of SARMs. The atrophy is a result of the enhanced expression of MAFbx and MuRF1, which are ubiquitin ligases and form a part of the ubiquitin proteasome system that is responsible for the decomposition of proteins and the decreased IGF-I function. SARMs inhibited the activity of the ubiquitin ligases and enhanced that of IGF-I (Jones et al. 2010). In a model of muscle atrophy in mice, GLPG0492 partially prevented the development of atrophy and caused hypertrophy of muscle fibers in a dose-dependent manner. The efficiency of the SARMs representative in this model is comparable to that of testosterone propionate, and the effect is achieved by affecting the signal pathways which regulate the homeostasis of the muscles (Blanqué et al. 2014).

Ostarine (S-22), which is the field leader of SARMs, was able to reduce muscle loss and to decrease the total fat percentage, with minimal side effects on the prostate (Zilbermint and Dobs 2009). In a double-blind study in postmenopausal women and older men, Ostarine increased lean body mass and also had a favourable effect on insulin resistance. Similarly, to the other selective modulators, in a study in postmenopausal women and men over the age of forty-five, Ostarine caused a significant increase in the reduced lean body mass (Dobs et al. 2013). An increase in muscle strength and endurance in mice treated with the GLPG0492 modulator was observed in a Duchenne muscular dystrophy model (Cozzoli et al. 2103). The intake of MK-0773 for a period of 6 months by 170 women with sarcopenia led to a significant increase in muscle mass and physical strength (Papanicolaou et al. 2013). The transdermal modulator (LY305) restored the muscle mass in a model of muscle atrophy in test animals. Moreover, this modulator did not cause significant changes in the values of hematocrit and high-density lipoproteins (HDL) (Krishnan et al. 2018). Another non-steroidal SARM that is considered suitable for the treatment of sarcopenia and cachexia is SARM2f. It was used in various models of malignant cachexia in rats and restored the body mass as well as increased the weight of m. levator ani without enlarging

the prostate or seminal vesicles (Morimoto et al. 2017). SARM2f demonstrated its anabolic effects in muscle tissue and decreased the lipid levels in monkeys as well (Morimoto et al. 2020). The rate of fractional synthesis of proteins from different muscles on the tenth day of administration of selective androgen receptor modulators can be measured and may provide early biomarkers for determining the expected increase of lean body mass and muscle weight of the corresponding muscles (Shankaran et al. 2016).

Effects on Nervous System

SARMs are believed to have a neuroprotective effect. For example, RAD140 also known as testolone delayed the programmed nerve cell death in various neurodegenerative models in rats. The mechanisms of this neuroprotective effect were related to MAPK (mitogen-activated protein kinase) - signal pathways (Jayaraman et al. 2014). It can be speculated that this effect of RAD140 could be used in the treatment of Alzheimer's and other neurodegenerative diseases. The selective androgen receptor modulators also have a favourable effect on age-related cognitive deficit. It is assumed that they increased the levels of androgen receptors in our brain and had an antagonistic effect on disorders of hippocampus-dependent exploration of new locations (Acevedo et al. 2008). Moreover, in mice, the selective androgen receptor modulator AC-105 improved the condition of anxiety. If AC-105 is used in combination with the selective estrogen receptor modulator (SERM) - AC-186, it enhances the activity of amyloid-β degrading enzymes, thus reducing the concentration of this group of peptides that are strongly associated with the development of Alzheimer's disease. Another effect of the combined application of these substances was the improvement of cognitive abilities and elevated levels of AR in the brain. This suggests that such a combination could be used in the treatment of patients with Alzheimer's disease (George et al. 2013). NEP 28 is another representative of SARMs, which in addition to its favourable effects on bone and muscle tissue, also had a neuroprotective effect (Akita et al. 2013).

SARMs and Positive Doping Tests

As SARMs are freely available for everyone on the Internet professional athletes can purchase them as well. Already there are reports for positive doping tests due to the use of different representatives of SARMs in professional sports. The number of positive tests increased since the year 2010. For example, the professional basketball player Joakim Noah who played for more than a decade in NBA (National Basketball Association) tested positive with the representative Ligandrol (LGD-4033) in 2017. He was completely cooperative during the investigation, and it was accepted that the positive result occurred due to an unintentional use. This is very likely to be true because SARMs are present in different dietary supplements without their presence being announced. In the end the player was suspended for twenty matches (Cacciola and Vorkunov 2017). Another case of positive doping tests occurred in the UFC (Ultimate Fighting Championship) in 2018. The forbidden substance found after the doping tests was

the aryl-propionamide analogue Ostarine. The following athletes were suspended: Augusto Mendes, 36, of Glendale, Ariz., tested positive for ostarine following an out-of-competition test conducted on March 7, 2018; Marvin Vettori, 25, of Mezzocorona, Italy, tested positive for ostarine following an out-of-competition test conducted on August 6, 2018; Sean O'Malley, 24, of Phoenix, Ariz., tested positive for ostarine following out-of-competition tests conducted on September 5, 2018 and December 8, 2018; Nicco Montano, 30, of Albuquerque, N.M., tested positive for ostarine following an out-of-competition test conducted on October 25, 2018. They duration of the suspension for all of them was 6 months. Similarly, to the case with Joakim Noah the reason for SARMs intake may be the use of contaminated dietary supplements. Sports professionals should be very careful when using dietary supplements and should pay a lot of attention when reading the constituents. Otherwise, they can suffer an unexpected suspension (USADA 2019). A list with the different names of SARMs to look for on the label of a supplement is provided by Van Wagoner et al. (2017) (see references).

The Jamaican 400m runner Bobby-Gaye Wilkins was banned for two years after using a performance-enhancing substance. Wilkins tested positive for the banned substance andarine (S4, GTx-007) at the world indoor championships in Doha, Qatar, in March 2010. The Russian athletes Svetlana Denyaeva-Biryukova, Roman Semakin, Nadezhda Mokeeva, Tatyana Dektyareva and Irina Yumanova all served a 2-year ban by IAAF (International Association of Athletics Federations) after respresentatives of SARMs or their metabolites were found in their doping samples. The hurdling professional Thomas Goller served as well a 2-year ban by IAAF from 2010 to 2012 for using selective androgen receptor modulators. Azerbaijan's Ethiopian-born 3,000 meters steeplechase winner Chaltu Beji turned positive during a doping test at the athletics competition in Baku, 2015. Beji provided urine sample which contained the banned anabolic agent ostarine. Further testing at the World Anti-Doping Agency-accredited laboratory in Moscow followed. A B-sample was requested following the initial failure, but the result again showed traces of the product (Butler 2015). According to WADA coaches actively involved in doping can be banned. Rules in the new code also seek to drive the nonconforming coaches out of the sport by giving athletes a stronger incentive not to work with them. Moreover, there can be sanctions for athletes that associate with coaches or support personnel serving a ban. Such was the case with former University of Virginia coach Martin Maric, who tested positive himself (with ostarine) and put not only himself at risk by coaching while serving a doping suspension, but also his athletes.

Up to now the number of positive doping tests due to AAS usage remains a lot higher than the number of positive tests after SARMs detection. Nowadays the most appropriate methods for detecting the presence of SARMs during doping control in different specimens (urine or blood plasma) are liquid chromatography, mass spectrometry or liquid chromatography tandem mass spectrometry. Liquid chromatography coupled with mass spectrometry (LC-MS) is an advanced method used in many clinical laboratories because of the many advantages it possesses. Some of them include detecting molecules in extremely low concentrations (in picograms per milliliter (pg/mL)), very high sensitivity, specificity, short analysis

times. Although there are a lot of studies on LC-MS or GC-MS (gas chromatography-mass spectrometry), it seems that they should still be optimized to avoid the false positive results due to the structural similarity of active metabolites of SARMs with androgen receptor antagonists such as flutamide (Perrenoud et al. 2016). There was a case report regarding an in-competition female athlete urine sample, in which metabolites of S-4 were detected, proving that the athlete used andarine for better physical performance (Miklos et al. 2018).

SARMs and Their Side Effects

The knowledge for SARMs up to now still makes them an attractive future option in the treatment of a great number of diseases, such as osteoporosis, cachexia, sarcopenia, benign prostatic hyperplasia, neurological diseases with cognitive deficits, hypogonadism, sexual dysfunction, breast cancer and option for effective contraception in men. On the other hand, their use, including by athletes, is associated with a number of adverse side effects (Geyer et al. 2014). However, most of them are of low frequency and reversible. The most common side effects are related to elevated liver enzymes and changes in various lipid fractions. There is still insufficient data on what the side effects of SARMs would be in the long-term use. Despite this fact SARMs are thought to be far more sparing than AAS. AAS provoke responses from the body which very often significantly reduce the quality of life. Some of them can be even fatal. What do we know about the side effects of SARMs in healthy individuals and in experimental models with animals or humans up to now? For example, after an intake of LGD 4033 for 21 days by healthy men the following adverse side effects were reported: a decrease of plasma levels of the sex hormone binding globulin (SHBG), triglycerides, HDL and FSH (Basaria et al. 2013). The changes found were manageable, with lipid and hormone concentrations returning to normal after discontinuation of the intake of LGD-4033. Administration for 2 weeks of the selective androgen receptor modulator C-6 in intact rats caused a decrease in gonadotropic hormone and serum testosterone levels. Later during the experiment, after the tenth week, a suppression of spermatogenesis occurred as well (Chen et al. 2005b).

In a postmenopausal model of osteoporosis in female rats, GTx-024 caused uterine weight gain and increased plasma phosphorus concentration (Hoffmann et al. 2019). Adverse side effects observed after Ostarine intake in humans included febrile neutropenia, pneumonia and progression of a present malignant disease (Dobs et al. 2013). Ostarine is the representative with the highest number of clinical trials performed. In a large-scale experiment with women who suffer from sarcopenia, it was reported that the intake of MK-0773 did not cause androgenization, but in some of the respondents, there was, albeit transient, an increase in transaminase liver enzymes (Papanicolaou et al. 2013). Another study reported that in healthy men and postmenopausal women the administration of GSK2881078 caused a decrease in HDL and SHBG. In women, these effects occurred even at lower doses than in men. One woman was reported to have a rash, and two men had elevated creatine phosphokinase levels after physical exercise (Clark et al. 2017). The selective modulator RAD140, in various in vivo

and in vitro models, was found to cause decreased appetite and weight, elevated liver enzymes (AST and ALT), as well as hypophosphatemia (Hamilton et al. 2019). After the application of the new representative of SARM - PF-06260414 in healthy people of different ethnics (Japanese and humans from countries of the West), the tolerance of the preparation was good, but there were slight adverse effects, such as headache and increased ALT levels (Bhattacharya et al. 2016).

Several case reports about liver injury due to SARMs intake are available in the literature. For instance, a 32-year-old man had a daily intake of 10 mg of Ligandrol (LGD-4033) for 2 weeks in order to increase his muscle mass. He was hospitalized. The main reasons for the hospitalization were elevated liver enzymes and presence of jaundice. Some of the laboratory results were the following: aspartate aminotransferase 91 IU/L, alanine aminotransferase 229 IU/L, alkaline phosphatase 88 IU/L, total bilirubin 2.4 mg/dL. Other symptoms included fatigue, pruritus, and weight loss. In the hospital magnetic resonance cholangiopancreatogram was performed and a small hepatic cyst and splenomegaly were found. A result from liver biopsy revealed cholestatic hepatitis, portal, periportal and perisinusoidal fibrosis. No information about liver problems was present in the medical, social, surgical, and family history of the man. Hepatitis A, B, and C markers were negative and the conclusion of the physicians was DILI (drug induced liver injury) by the Ligandrol intake. The patient remained in hospital for 24 hours and was prescribed appropriate drugs. We have to bear in mind the fact that the dosage used by this young man was many times higher than the SARMs clinically effective dosages usually used in human trials and experimental animal models (0.1 mg, 0.3 mg, and 1.0 mg) (Barbara et al. 2020).

Another interesting case report stated that a 24-yaer old man developed anorexia, jaundice, wight loss (around 5 kg) and nausea. This was the consequence of an intake of Ligandrol (LGD-4033) capsules for a period of 9 weeks as a gym supplement. Some of the elevated parameters connected with the liver included: bilirubin, 116μmol/L (reference, <30); alanine aminotransferase (ALT), 273 U/L (reference, <45); aspartate aminotransferase (AST), 111 U/L (reference, <45); alkaline phosphatase (ALP), 289 U/L (reference, <100). Liver tests normalized after a period of 4 months (Flores et al. 2020). There was no information concerning the dosage of LGD-4033 used but binge drinking once a month was documented. Third case report described a 49-year-old man presented with jaundice and itching of 5 weeks duration. He regularly took an antidepressant (venlafaxine) for 11 months. Four months before the symptoms have occurred the man used RAD-140 (testolone) for 4 weeks followed by an intermittent use thereafter. Investigations showed the following: bilirubin, 291 μmol/L; ALT, 54 U/L; AST, 59 U/L; ALP, 327 U/L. There was no significant alcohol consumption. Biliary obstruction and other possible liver diseases were excluded. Liver histology results showed moderate cholestasis with ductopenia and minimal fibrosis and inflammation, consistent with drug-induced liver injury. All liver tests of the 49-year-old-man were normal when examined 12 months later (Flores et al. 2020). Once again, no information was given in this case report about the dosage of testolone used.

The risk of severe liver injury mostly depends on the dose used. Doses around 10 to 100 times higher than the ones used in clinical trials are highly likely to increase the risk. Otherwise, according to our knowledge, when the intake of SARMs is of the appropriate dose the side effects concerning the liver are very weak and quickly reversible. One possibility to escape the adverse effects on the liver can be the use of transdermal SARMs like LY305. This route of administration limits the exposure of the liver to selective androgen receptor modulators. One of the difficulties in determining the side effects of selective androgen receptor modulators in clinical trials is connected with ethics. This is due to the fact that very high dosages should be given to the volunteers in order to match the ones used in doping or by amateurs going to the gym.

Conclusions

SARMs are a class of molecules which gives us hope for the future. Holding the big advantage of tissue selectivity over AAS and their derivatives, SARMs can be a potential treatment for many socially significant diseases like amyotrophic lateral sclerosis, dermatomyositis, osteoporosis, breast cancer, sarcopenia, various types of cachexia, benign prostatic hyperplasia, hypogonadism, neurodegenerative diseases (Alzheimer's disease), stress urinary incontinence (SUI). SARMs have well-pronounced anabolic effects in bones and muscles and sparing androgenic effects in the prostate and seminal vesicles. However, as there is no approved representative of SARMs by the FDA, we still need further investigation about the side effects of these substances (their frequency, severity and reversibility as well). Further information is needed and about the extent of improvements of different important body functions SARMs can give us. Some clinical trials with SARMs have been terminated due to lack of efficacy, others were completed and already have results or still await them. Probably in the near future there will be more clinical trials to come. The selective modulators are a temptation in sports due to their strong anabolic effect enhancing the physical performance. Nevertheless, SARMs are included in the prohibited list of WADA and a significant number of positive doping tests in different types of sports were revealed. The selective modulators pose a threat to all sportsmen especially to amateurs who buy SARMs on their own from the internet, do not consult a doctor and are not familiar with the correct dosage for intake. So no matter if you are an amateur or a sports professional, a coach or a sports medicine doctor, if you are involved in sports it is better to be aware of the possible benefits and risks of SARMs.

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