# Risk factors for injury in talented soccer and tennis players

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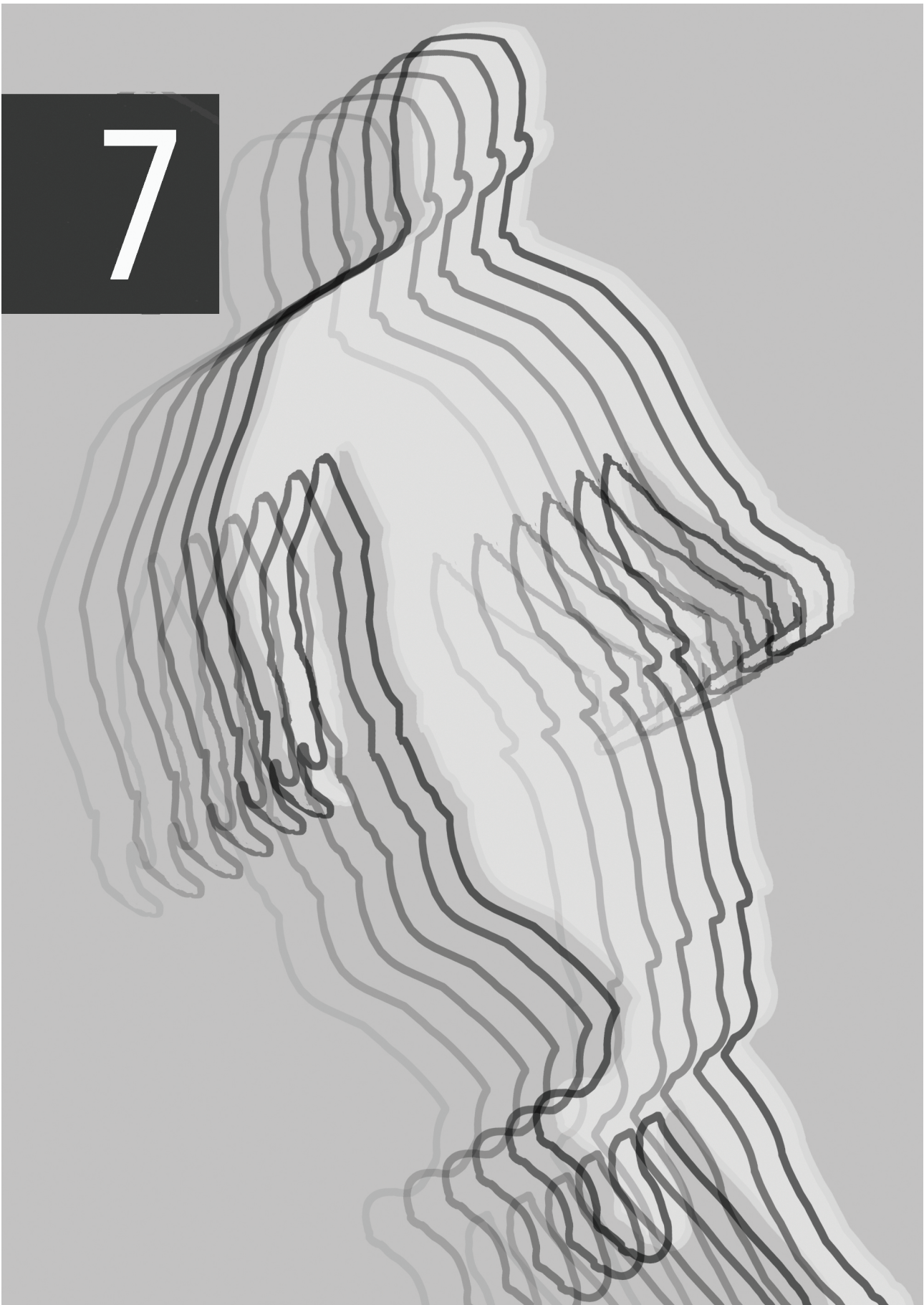

# CHAPTER 7

## GENERAL DISCUSSION

The aim of this thesis was to identify risk factors for injuries in talented adolescent athletes, specifically related to maturation-driven processes that are typical for this target group. More knowledge on these aspects can help to develop prevention strategies for injuries in these athletes.

## SUMMARY OF MAIN FINDINGS

The results of this thesis confirm that both tempo and timing of growth are risk factors in itself for injuries in talented soccer players. In chapter 2 we concluded that during the year of Peak Height Velocity (PHV), talented soccer players have significantly more traumatic injuries and seem to miss significantly more days from training and competition. Chapter 3 showed that anthropometric factors, i.e., growth, BMI-increase and low fat percentage, can be used to recognize players who are at risk for injuries. In chapter 4 we concluded that later maturing players have overuse injuries both before and during the year of PHV. In chapter 5 we found that adolescent risk-taking in talented male tennis players contributed significantly to time loss overuse injuries. Chapter 6 addressed the relationship between meta-cognitive skills and overuse injuries. High self-monitoring skills were related to less time loss overuse injuries in female tennis players. High reflection skills were related to higher overuse severity scores.

## THEORETICAL CONSIDERATIONS OF THE ADOLESCENT GROWTH SPURT

The fact that we followed talented soccer players longitudinally around an individually determined period of PHV led to better understanding on how the occurrence of injuries fluctuates in this period. A period of intensive growth was related to an increase in the occurrence of injuries in talented soccer players. In chapter 2, it was shown that this increase can be seen over a longer period, the year in which PHV takes place. Chapter 3 supported the fact that this increase can also be seen short-term, within a month after a period of growth. In chapter 2, we only found a significant increase in traumatic injuries, that result from a specific, identifiable event. This is in line with studies that described that as a result of intensive growth, changes in body structures take

place, such as joint stiffness in hip, knee and ankle, reduced flexibility of lower back and hamstrings and problems in motor coordination. These physical changes have been related to traumatic injuries [11, 25]. In chapter 3, growth was related to an increase in injury occurrence in the month afterwards. In this study, traumatic and overuse injuries were taken together as an independent variable, and over half of the injuries in this study were overuse injuries. It seems therefore that growth was not only related to an increase in traumatic injuries, but also in overuse injuries. Overuse injuries in talented athletes have been related to rapid increases in total load placed on the athlete [11, 31]. It could be, that as a result of growth, athletes have a temporarily lower capacity. In the same period in which they participate in talent development programs, training and match load, often referred to as external load, that is placed upon players stays the same or even increases [8, 32]. As a result, the internal load (the actual amount of physiological stress experienced by an individual athlete during training and competition) increases (Impellizieri et al.2005). Several studies have shown a relationship between internal load and injuries [3, 12, 13]. In this regard, it is interesting that the internal load of training sessions, is often perceived higher by youth soccer players themselves, than intended by their coach [4]. It could well be, that this discrepancy in intended and perceived load holds true even more in players who are experiencing a growth spurt.

Later maturing talented soccer players seem to have an extra disadvantage around periods of intensive growth, compared to their earlier maturing counterparts. Besides an increase in injuries in the year in which they have their PHV, they experience substantially more overuse injuries than earlier maturing players, both before and during their year of PHV. It seems that they have to overcome a period in their talent development process that is 'hard to survive'. Before their PHV, they are surrounded by (earlier maturing) players that are physically more developed and therefore taller, heavier and stronger. Since, later maturing players are chronologically older when their PHV commences, they play in older age groups, and are exposed to more, longer training sessions of higher intensity and play more intensive matches, while at the same time needing energy to mature [9, 15, 32]. This results in a higher internal training load compared to earlier maturing players,

that again can be the cause for overuse injuries. A recent study that points in the same direction is that of Stracciolini [29], on the relative age effect in relation to injuries: the relatively older individuals within an age group sustain lesser injuries than the ones that are relatively younger. From past research we know that chronologically younger athletes (the 'relative age effect') and/or biologically younger athletes (later maturing) have a smaller chance of being selected for talent development programs [8, 10, 16]. Apparently, being biologically or chronologically younger is also a disadvantage for an athlete when it comes to sustaining injuries. This indicates a 'double disadvantage' for the later maturing athlete.

## THEORETICAL CONSIDERATIONS OF ADOLESCENT RISK-TAKING AND META-COGNITIVE SKILLS

Risk-taking is typical for developing adolescents [28]. It was positively related to overuse injury severity and to time loss injuries in talented male tennis players. Crone & Dahl (2012) suggest that risk-taking is partly caused by heightened sensitivity to social evaluation, particularly by social groups that are of importance to an adolescent. The social context of elite sport (trainers, coaches, other athletes) is probably of high importance to talented athletes; they make many training hours, often at the cost of other age-typical non-sports activities. At the same time, the culture of elite sport has been described as a 'culture of risk' itself: athletes willingly accept, minimize or ignore risks of pain and injury and athletes sometimes tend to promote this among each other [22, 27]. This might make developing athletes extra vulnerable: because of structural and functional brain development that results from maturation, and because of the social context in which they move.

However, talented athletes are probably not passively accepting the risks of injuries. Chapter 6 showed that the meta-cognitive skill of self-monitoring possibly protects talented athletes from having time loss overuse injuries. Self-monitoring handles about the awareness an athlete has about his or her actions during execution. Female tennis players with high self-monitoring skills than their peers, might be better able to keep track of their training load and their (bodies') response

to it (their internal training load) and react in an injury preventive manner. The self-monitoring skill typically makes an athlete aware of what he or she feels 'right here, right now'. This could be of importance in the use of Athlete Self-Report Monitoring systems (ASRM). ASRM is increasingly used in elite sport settings to monitor performance and to prevent injuries. It assumes that players are capable of giving feedback in an honest and meaningful way, for example the way they perceived training and match load [26]. Only then, such systems will be useful in the prevention of injuries.

## STRENGTHS, LIMITATIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

In this thesis, over 200 talented soccer players and 74 talented tennis players were prospectively monitored to find risk factors related to maturational processes. In the first cohort of soccer players (2004-2006) injuries were monitored for three years around their individually determined age of Peak Height Velocity (APHV), providing insight over a longer period. The second cohort (2012-2013) was followed for one season, in which height and body mass were measured on a monthly basis, while fat free mass was monitored on a 3-month interval. The advantage of this design was that we could determine short-term influences of growth and maturation. In the cohort of tennis players we used a new instrument to monitor overuse injuries: the Oslo Sports Trauma Research Center Overuse Injury Questionnaire [5]. This provided detailed insight in the occurrence and severity of overuse injuries.

The injury rates we found in the talented soccer players were comparable or somewhat lower than those found in other studies [3, 14]. The select group of 26 players that could be followed for three years around their PHV is a reasonable explanation for this, since it indicated a selection bias in favour of players selected by the staff. We will discuss this below. In chapter 5 and 6, we focused on overuse injuries in talented tennis players. The proportion of overuse injuries in our data (77% of total injuries) was comparable to that found by Stracciolini et al. [29] and was higher than that found in a study of Hjelm et al. [17]. Differences are

probably due to differences in population and measurement method. Hjelm et al. (2010) studied recreational tennis players and only included time loss overuse injuries.

A potential limitation of the work described in this thesis is that the influence of the adolescent growth spurt, risk-taking and metacognitive skills were studied separately, but that they may interact. Due to relatively small sample sizes, it was not possible to use a multidisciplinary approach in which these factors were combined. It is well possible, that a combination of for example being late mature, experiencing a period of PHV and having a high amount of risk-taking and low monitoring skills, is disastrous for the development of injuries. Future research should try to combine these factors in larger groups of athletes.

In chapter 2 and 4, we included soccer players we were able to follow for three years around Peak Height Velocity, which indicates a selection bias in favour of players that stayed part of the talent development program. It is well possible that injuries were the reason players dropped out of the program and that the injury problem is even bigger in this group. We speculate that the injury problem is even bigger for players with late maturation than was found in chapter 4: we made a distinction in earlier and later maturing players by median split. Of these later maturing players, only two officially fall in the category of late maturation (having a skeletal age of more than one year behind their chronological age). Therefore, future research could include players dropping out of selection programs and extent the focus on players maturing at later moments than the ones in our sample.

In chapter 2, 3 and 4, we used conventional methods to monitor injuries, with no particular focus on overuse injuries. This probably resulted in an underestimation of the real overuse problem. The increase in overuse injuries over three years around PHV seemed more gradual, and did not really seem to peak into PHV. However, when we look at the medical attention overuse injuries only, a steeper increase in the number of overuse injuries into the year of PHV indeed can be seen compared to the year after (from just over 12 pre-PHV to over 20 during PHV and 23 post-PHV). Also, some other overuse related differences between earlier and later maturing players that resulted from this study are

very interesting and yield for further investigation: in the group of later maturing players, 23 overuse injuries related to the knee were found, compared to only 7 in the earlier maturing group. Osgood Schlatter syndrome occurred in both groups, but the average days missed because of it, were 58 in the later maturing group, compared to 15 in the earlier maturing players. In recent years, new instruments have been developed to record the extent and severity of overuse injuries more accurately, such as the Oslo Sports Trauma Center Questionnaire [5]. These were not available when we performed our studies in soccer players, but using them would probably shine more light on the development of overuse injuries around the adolescent growth spurt.

In chapter 4, risk-taking was measured using the Iowa Gambling Task (IGT). Although widely used in clinical and non-clinical populations as a measure for risk-taking (including health-related risk-taking), there is debate about the exact behavioural construct that is measured by the task: the task seems a complex behavioural measure assessing a complex construct. For example, one suggestion from literature is that the last trials of the task measure 'real' risk-taking (when the subject has figured out the rules for gains and losses), as the first blocks depend more on 'decision making under ambiguity' (when the outcome is completely unknown) [2]. However, it is unclear when this shift takes place, and this may differ from person to person. Future research should investigate the relationship between these proposed alternative IGT scores (such as the scores in the last two or three blocks) and injury occurrence.

Because the IGT was taken only at the start of the season, no insight could be provided in the development of risk-taking in talented athletes over longer periods. Risk taking behavior over longer periods in time is particularly interesting in developing athletes and recommended for future research. Also, future research should take into account the relationship between the IGT and real-life risk-taking behavior that can be related to injuries (for example the relationship with training or competing while in pain or despite functional limitations). Last, the relationship with traumatic injuries should be studied.

Meta-cognitive skills were assessed with a questionnaire measuring meta-cognition in a general learning context. It is suggested that from the age of 12, meta-cognitive skills become more domain general, and learners will use them in other contexts than the context in which they learn them, although debate about the conditions for successful transfer between domains continues [19, 20, 24]. However, the fact that for many athletes, health goals will be inherent to performance goals, might have influenced the results. It is well possible that athletes filled out this questionnaire while thinking about their sport performance goals and not about their health. Self-regulation questionnaires have been developed for different domains, such as healthy eating [30]. It would be interesting to use (or develop) self-regulation questionnaires that are focused on health management and study the relationship with injuries in talented athletes.

At last, the results of the current thesis raise questions about possible interventions addressing the risk factors specifically related to maturation-driven processes that are typical for this target group. Future studies should investigate the effect of possible interventions in periods of intensive growth and maturation, such as variations in type of training or alterations in training load.

## CONCLUSION

This thesis showed that:

- In talented soccer players, the adolescent growth spurt is related to an increase in traumatic injuries. This can be seen short-term, within a month after a period of growth, but also long-term, in the year in which PHV takes place.
- Later maturing talented soccer players are especially at risk for injuries. They experience substantially more overuse injuries than earlier maturing players, not only during their year of PHV, but also in the year before.
- In talented male tennis players, higher risk-taking is related to more time loss overuse injuries.
- The meta-cognitive skill of self-monitoring can possibly reduce injury risk in talented tennis players.

## PRACTICAL IMPLICATIONS

The findings of this thesis can be used to protect talented athletes in periods in which they are at high risk of maturity-driven processes, such as the adolescent growth spurt and risk-taking. These periods should be determined individually. The maturity offset protocol [20] provides a valuable first indication of when the athletes will have their growth spurt. This tool should be used around the age of 12 in boys and around the age of 14 in girls, at least before the early maturing players start having the Peak Height Velocity. This gives trainers, coaches and other support staff a good indication of the variation in maturity of the players they are working with. They should be aware of the heightened vulnerability of later maturing players. Increased awareness should start at times when their teammates are experiencing their growth spurt (but later maturing players are not yet). From this period on, players could be split up in some parts of the training, based on biological age instead of chronological age. This could decrease the chance on injuries in this group. The period between 13.5 and 14.5 years of age appears to be a period in which it is particularly difficult to balance training and match load in talented male athletes: players who mature later are in a vulnerable period because they are surrounded by more developed players, whereas players maturing at an early age are vulnerable because of their PHV.

During the year of PHV, careful measurement of growth at regular intervals (for example every four weeks) can be considered, to identify periods of intensive growth, and increased injury risks as a result in the weeks afterwards.

The Iowa Gambling Task can be used to detect players who are likely to take more risks. Feedback about risk-taking behavior can be given to trainers and coaches, but also to players themselves. Coaches and players should be aware of the fact that risk-taking behavior mainly takes place in contexts that are of high importance, and under pressure of peers.

To conclude, we consider the Oslo Sports Trauma Research Centre Questionnaire as an excellent tool to follow the development of overuse

injuries. In using this tool, athletes should be educated to develop self-monitoring skills that could help them in preventing themselves from injuries. We recommend future research to come up with clear recommendations on injury prevention specifically targeting young players at high risk of injury due to maturation-driven processes.

# REFERENCES

1. Blimkie CJ, Lefevre J, Beunen GP, Renson R, Dequeker J, van Damme P. Fractures, physical activity, and growth velocity in adolescent Belgian boys. Med Sci Sports Exerc 1993; 25(7): 801-808.
2. Brand M, Recknor EC, Grabenhorst F, Bechara A. Decisions under ambiguity and decisions under risk: correlations with executive functions and comparisons of two different gambling tasks with implicit and explicit rules. J Clin Exp Neuropsychol 2007; 29(1): 86-99.
3. Brink MS, Visscher C, Arends S, Zwerver J, Post WJ, Lemmink KAPM. Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. Br J Sports Med 2010; 44(11): 809-815.
4. Brink MS, Frencken WG, Jordet G, Lemmink KA. Coaches" and "players" perceptions of training dose; not a perfect match. Int J Sports Physiol Perform 2014; 9(3): 497-502.
5. Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. Br J Sports Med 2013; 47(8): 495-502.
6. Crone EA, Dahl RE. Understanding adolescence as a period of social–affective engagement and goal flexibility. Nat Rev Neurosci 2012; 13(9): 636-650.
7. Dupont G, Nedelec M, McCall A, McCormack D, Berthoin S, Wisløff, U. Effect of 2 soccer matches in a week on physical performance and injury rate. Am J Sports Med 2010; 38(9): 1752-1758.
8. Elferink-Gemser MT, Jordet G, Coelho-E-Silva MJ, Visscher C. The marvels of elite sports: how to get there? Br J Sports Med 2011; 45(9): 683-684.
9. Elferink-Gemser MT, Huijgen BC, Coelho-E-Silva M, Lemmink KAPM, Visscher C. The changing characteristics of talented soccer players–a decade of work in Groningen. J Sports Sci 2012; 30(15): 1581-1591.
10. Figueiredo AJ, Gonçalves CE, Coelho-e-Silva MJ, Malina RM. Characteristics of youth soccer players who drop out, persist or move up. J Sports Sci 2009; 27(9): 883-891.
11. Ford KR, Myer GD, Hewett TE. Longitudinal effects of maturation on lower extremity joint stiffness in adolescent athletes. Am J Sports Med 2010; 38(9): 1829-1837.
12. Gabbett TJ. Influence of training and match intensity on injuries in rugby league. J Sports Sci 2004; 22(5): 409-417.
13. Gabbett TJ, Domrow N. Relationships between training load, injury, and fitness in sub-elite collision sport athletes. J Sports Sci 2007; 25(13): 1507-1519.
14. Le Gall F, Carling C, Reilly T, Vandewalle H, Church J, Rochcongar P. Incidence of Injuries in Elite French Youth Soccer Players A 10-Season Study. Am J Sports Med 2006; 34(6): 928-938.
15. Harley JA, Barnes CA, Portas M, Lovell R, Barrett S, Paul D, Weston M. Motion analysis of match-play in elite U12 to U16 age-group soccer players. J Sports Sci 2010; 28(13): 1391-1397.
16. Helsen WF, Van Winckel J, Williams AM. The relative age effect in youth soccer across Europe. J Sports Sci 2005; 23(6): 629-636.
17. Hjelm N, Werner S, Renstrom P. Injury profile in junior tennis players: a prospective two year study. Knee Surg Sports Traumatol Arthrosc 2010; 18(6): 845-850.

18. Impellizzeri FM, Rampinini E, Marcora SM. Physiological assessment of aerobic training in soccer. J Sports Sci 2005; 23(6): 583-592.
19. Jonker L, Elferink-Gemser MT, Toering TT, Lyons J,Visscher C. Academic performance and self-regulatory skills in elite youth soccer players. J Sports Sci 2010;, 28(14): 1605-1614.
20. Mirwald RL, Baxter-Jones AD, Bailey DA, Beunen GP. An assessment of maturity from anthropometric measurements. Med Sci Sport Exerc 2002: 34(4): 689-694.
21. Myklebust G, Hasslan L, Bahr R, Steffen K. High prevalence of shoulder pain among elite Norwegian female handball players. Scand J Med Sci Sports 2013; 23(3): 288-294.
22. Nixon HL. Accepting the risks of pain and injury in sport: Mediated cultural influences on playing hurt. Sociol Sport J 1993; 10: 183-183.
23. Perkins DN, Salomon G. Are cognitive skills context-bound? Educ Res 1989; 18(1): 16-25.
24. Pintrich PR, Zusho A. (2002) The development of academic self-regulation: The role of cognitive and motivational factors.
25. Quatman-Yates CC, Quatman CE, Meszaros AJ, Paterno MV, Hewett TE. A systematic review of sensorimotor function during adolescence: a developmental stage of increased motor awkwardness? Br J Sports Med 2012; 46(9): 649-655.
26. Saw AE, Main LC, Gastin PB. Role of a self-report measure in athlete preparation. J Strength Cond Res 2015; 29(3): 685-691.
27. Schnell A, Mayer J, Diehl K, Zipfel S, Thiel A. Giving everything for athletic success!–Sports-specific risk acceptance of elite adolescent athletes. Psychol Sport Exerc 2014; 15(2): 165-172.
28. Steinberg L . A social neuroscience perspective on adolescent risk-taking. Dev Rev 2008; 28(1): 78-106.
29. Stracciolini A, Levey FH, Casciano R, Howell D, Sugimoto D, Micheli LJ. The Relative Age Effect on Youth Sports Injuries. Med Sci Sports Exerc 2016; 48(6): 1068-1074.
30. De Vet E, De Ridder D, Stok M, Brunso K, Baban A, Gaspar T. Assessing self-regulation strategies: development and validation of the tempest self-regulation questionnaire for eating (TESQ-E) in adolescents. Int J Behav Nutr Phys Activ 2014; 11(1): 1.
31. Visnes H, Bahr R. Training volume and body composition as risk factors for developing jumper's knee among young elite volleyball players. Scand J Med Sci Sports 2013; 23(5): 607-613.
32. Wrigley R, Drust B, Stratton G, Scott M, & Gregson W. Quantification of the typical weekly in-season training load in elite junior soccer players. J Sports Sci 2012; 30(15): 1573-1580.