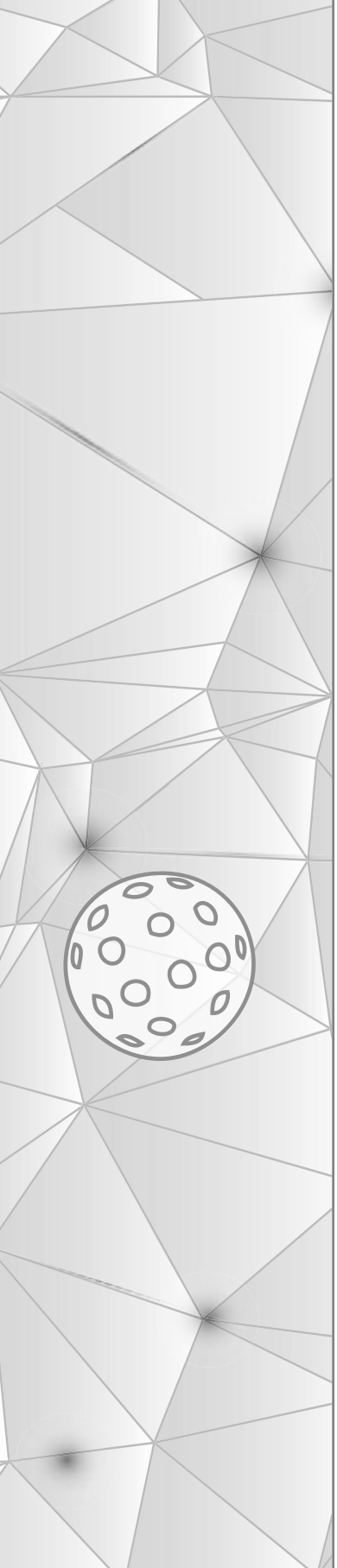
Enhancing Performance & Preventing Injuries in Team Sport Players

van der Does, Hendrike

1



General Introduction

In indoor team sports like basketball, volleyball and korfball the game efforts are known to be high [6,21,22,40] . During a volleyball game, players jump approximately 60 times [30,35,42] . In a basketball game, players perform up to 70 jumps per game, and approximately 980 running movements [7] . These jumping and running movements include sudden accelerations, decelerations and changes of direction in anticipation to the ball and other players. Furthermore, they are executed in small field dimensions, ranging from 18m by 9m up to 40m by 20m. This evokes short bouts of high-intensity to near maximal effort that is alternated with periods of low-intensity activities [20,21,42,43] . The frequency, types of movements and activity patterns make these types of sport very complex and demanding. Consequently, well-developed physical capacities and a good movement technique are required to perform optimal and prevent injuries.

To develop these physical capacities and this movement technique, regular training is combined with recovery in between. In addition to the physical stress of training, psychosocial stress and recovery also plays an important role [29]. It is assumed that changes in training load, stress and recovery need to be monitored to enhance performance and prevent injuries [29]. Figure 1 depicts the outline of this approach as introduced by Kenttä and Hassmén (1998). It also shows that physical charateristics and movement technique of players can be assessed at the start of the season in order to determine the injury risk.

Figure 1. Model measuring physical capacities & movement technique and monitoring training load, recovery and psychosocial stress and recovery over the course of a season in team sport players. Adapted from Kenntä and Hassmén (1998).

MONITORING

Performance

There are several factors that influence game performance in indoor team sports such as strength of the opponent, ranking in the competition, tactics, first half performance, physical and mental fitness of individual players, and so forth [23,28,41] . This results in a high variability between games, making game analyses unsuitable to assess changes in physical performance of individual players [23] . Currently, performance is mainly measured by determining physical capacities once or twice during the season for example with gold standards like the 30-second Wingate [5] and VO_2max test [25] to measure anaerobic power and aerobic endurance respectively. While these tests are suitable to measure anaerobic power and aerobic endurance, they are not very sport specific for indoor team sports. In sports like volleyball and basketball physical capacities are measured with more sport specific field-tests like repeated sprint tests, intermittent running tests and jump tests [6,10,11,13,17,20] . The type of activities of these sports also shows the importance of anaerobic (explosive) power and changes of

direction/agility. Agility tests are more specific in comparison to the intermittent running tests when looking at movement characteristics during games. Therefore to evaluate performance more sport-specific, next to anaerobic power and aerobic intermittent endurance, agility should be measured.

Training load & Recovery

To prevent players from becoming injured and optimize performance over time, coaches and players struggle daily with finding the right balance between what they do (training load) and what they are capable of (capacities and technique) to eventually push boundaries. The training load comprises of an external and internal training load. A too high training load can negatively affect the outcome in terms of performance decrement or injury occurrence (Figure 1). The external training load is the load as imposed on the player. This is determined by frequency, duration, intensity and variation of the activities and should be applied regularly to optimize performance [26] . Due to individual differences in capacities the impact of external training load, which is the internal training load, differs between players [29] . Tools like the Rating of Perceived Exertion (RPE) and Heart Rate (HR) monitors, give insight in the internal training load [19,26] . Next to training load, recovery is also important in the process of training and adaptation (Figure 1). The amount of recovery needed after training depends on the internal training load. Thus, a higher internal training load requires more recovery. It is assumed that a balance between internal training load and recovery is needed to optimize performance and prevent injuries. Individual monitoring of this process over the course of a season will give adequate insight and allow for on-time interventions. Research up until now showed a decrement in field-test performance after a period of intensified training load, while a period of reduced training load increased field-test performance [12-14] . Monitor studies relating training load to field-test performance over the season are limited and show improved performance with increased training duration in the week before testing [10] . This indicates the need for monitoring studies over the course of a season that measure performance more regular.

Psychosocial stress & recovery

Recent studies show the importance of psychosocial stress and recovery to enhance performance and prevent injuries [11,12,17] . Psychosocial stress arises when there is a perceived imbalance between expectations and performance capabilities. This imbalance can be perceived in sports, but also in work, home situations, or from the interaction with people and/or (personal) life events [27,29] . These additional stress

factors also influence the response to the imposed training load and the recovery needed. A tool like the Recovery Stress Questionnaire Sport (RESTQ-Sport) [27,37] can give insight in psychosocial stress and recovery related activities. Players fill out the questionnaire regularly, for example every three weeks. Since these activities are personal, changes over time should be compared with a players' own individual profile [27] . The process of training load, recovery and psychosocial stress and recovery has an effect on the outcome in terms of both performance and injury occurrence. Therefore continuous monitoring of these processes and their outcome is important.

MOVEMENT TECHNIQUE & INJURY

The load on the lower extremities in indoor team sports is high due to the running, jumping, sudden decelerations, cutting movements and changes of direction, this increases the injury risk [38,39]. In sports like basketball [16], volleyball [2] and floorball [39] 55% up to 77% of the injuries occur at the lower extremities, of which 27% to the knee and 22% up to 41% to the ankle [18]. Research shows about 30% of lower extremity injuries occur from sharp twist and turns, whereas 45 up to 86% occur from jump landing [3,4,34]. So the execution of the jump is crucial and in particular the technique and stability during the jump-landing phase. When poorly performed the load on the lower extremities increases, which in turn increases the injury risk of both knee and ankle [2,15,16,44]. An optimal jump-landing technique is relevant to efficiently absorb the impact forces of the landing, decreasing the loads on the lower extremities [1,32]. Studies have shown that a suboptimal jump-landing technique (Figure 2) and less landing stability are related to acute knee [24,36] and acute ankle injury occurrence respectively [33,46].

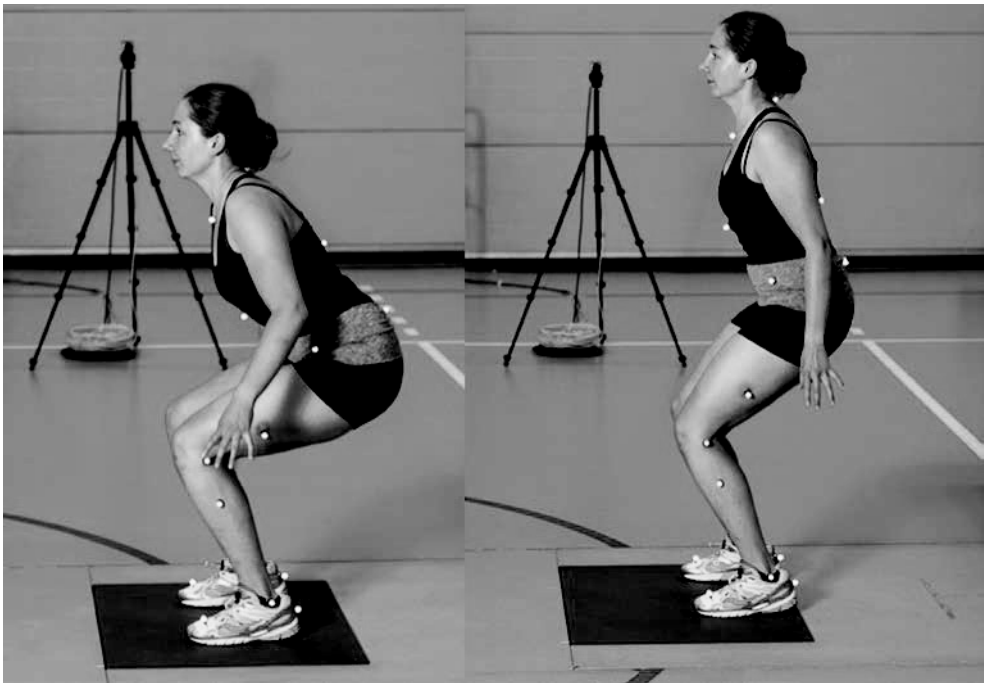


Figure 2. Example of an optimal (left) and suboptimal (right) jump-landing. On the left the player has good knee and hip flexion, on the right the joint flexion is limited.

A limitation of current research is the focus on acute injuries, while overuse injuries also account for a great part of the injuries. In basketball [15] and volleyball the jumpers knee is the most common overuse injury, due to the repetitive jumping, with a prevalence of 45% and 32% respectively [31,47]. Recently it was suggested that suboptimal landing technique is also a potential indicator of overuse injuries [8,9,45]. Screening tools that measure landing stability and technique of a player are therefore important to incorporate at the start of the season to get insight in risk profiles. By monitoring the injury occurrence the relation can be explored between the risk profiles at the start of the season and the injuries over the season. This knowledge can guide training and prevention programs of both acute and overuse injuries over the course of a season.

THESIS OUTLINE

The aim of this thesis is two-fold. First to investigate if changes in training load, recovery and psychosocial stress and recovery are related to (field-test) performance and injury occurrence during the season. Secondly, to provide more insight in the

predictive value of movement technique measured at the start of season for injury occurrence during the season.

To reach these goals 129 male and female volleyball, basketball, korfball and floorball players were monitored over the course of two seasons. First, it was investigated to what extent anaerobic and aerobic energy systems were related to a team sport specific agility test.

Thereafter, training load and recovery and psychosocial stress and recovery were related to field-test performance in chapter 3. Since changes in psychosocial stress and recovery could also increase injury risk, the association with acute and overuse injuries is presented in chapter 4.

The following three chapters focus on the movement technique at baseline and the injury risk during the season. In the 5th Chapter the landing stability was investigated in relation to ankle injuries during the subsequent season. After that, Chapter 6 investigated the predictive value of both landing stability and landing technique at the start of the season for acute and overuse ankle and knee injuries over 2 seasons. Jump landing as risk factor for a jumper's knee was more closely investigated in the 7th Chapter.

The methods and results of Chapter 2 through 7 are discussed in the general discussion, after which the final conclusions are drawn. Lastly, the results are put into a practical perspective, giving implications for coaches, players and medical staff.

REFERENCES

1 Aerts I, Cumps E, Verhagen E, et al. A systematic review of different jump-landing variables in relation to injuries. J Sports Med Phys Fitness 2013;53:509-519.

2 Agel J, Palmieri-Smith RM, Dick R, et al. Descriptive epidemiology of collegiate women's volleyball injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train 2007;42:295-302.

3 Bahr R, Bahr IA. Incidence of acute volleyball injuries: a prospective cohort study of injury mechanisms and risk factors. Scand J Med Sci Sports 1997;7:166-171.

4 Bahr R, Karlsen R, Lian O, et al. Incidence and mechanisms of acute ankle inversion injuries in volleyball. A retrospective cohort study. Am J Sports Med 1994;22:595-600.

5 Bar-Or O. The Wingate anaerobic test. An update on methodology, reliability and validity. Sports Med 1987;4:381-394.

6 Ben Abdelkrim N, Castagna C, Jabri I, et al. Activity profile and physiological requirements of junior elite basketball players in relation to aerobic-anaerobic fitness. J Strength Cond Res 2010;24:2330-2342.

7 Ben Abdelkrim N, El Fazaa S, El Ati J. Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. Br J Sports Med 2007;41:69-75; discussion 75.

8 Bisseling RW, Hof AL, Bredeweg SW, et al. Are the take-off and landing phase dynamics of the volleyball spike jump related to patellar tendinopathy? Br J Sports Med 2008;42:483-489.

9 Bisseling RW, Hof AL, Bredeweg SW, et al. Relationship between landing strategy and patellar tendinopathy in volleyball. Br J Sports Med 2007;41:e8.

10 Brink MS, Nederhof E, Visscher C, et al. Monitoring load, recovery, and performance in young elite soccer players. J Strength Cond Res 2010;24:597-603.

11 Brink MS, Visscher C, Coutts AJ, et al. Changes in perceived stress and recovery in overreached young elite soccer players. Scand J Med Sci Sports 2012;22:285-292.

12 Coutts AJ, Reaburn P. Monitoring changes in rugby league players' perceived stress and recovery during intensified training. Percept Mot Skills 2008;106:904-916.

13 Coutts AJ, Reaburn P, Piva TJ, et al. Monitoring for overreaching in rugby league players. Eur J Appl Physiol 2007;99:313-324.

14 Coutts AJ, Wallace LK, Slattery KM. Monitoring changes in performance, physiology, biochemistry, and psychology during overreaching and recovery in triathletes. Int J Sports Med 2007;28:125-134.

15 Cumps E, Verhagen E, Meeusen R. Prospective epidemiological study of basketball injuries during one competitive season: ankle sprains and overuse knee injuries. J Sports Sci Med 2007;6:204-211.

16 Dick R, Hertel J, Agel J, et al. Descriptive epidemiology of collegiate men's basketball injuries: National Collegiate

Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. J Athl Train 2007;42:194-201.

17 Faude O, Kellmann M, Ammann T, et al. Seasonal changes in stress indicators in high level football. Int J Sports Med 2011;32:259-265.

18 Fong DT, Hong Y, Chan LK, et al. A systematic review on ankle injury and ankle sprain in sports. Sports Med 2007;37:73-94.

19 Foster C. Monitoring training in athletes with reference to overtraining syndrome. Med Sci Sports Exerc 1998;30:1164-1168.

20 Gabbett T, Georgieff B, Domrow N. The use of physiological, anthropometric, and skill data to predict selection in a talent-identified junior volleyball squad. J Sports Sci 2007;25:1337-1344.

21 Girard O, Mendez-Villanueva A, Bishop D. Repeated-sprint ability - part I: factors contributing to fatigue. Sports Med 2011;41:673-694.

22 Godinho M, Fragoso I, Vieira F. Morphologic and anthropometric characteristics of high level Dutch korfball players. Percept Mot Skills 1996;82:35-42.

23 Gregson W, Drust B, Atkinson G, et al. Match-to-match variability of high-speed activities in premier league soccer. Int J Sports Med 2010;31:237-242.

24 Hewett TE, Myer GD, Ford KR, et al. Biomechanical measures of neuromuscular control and valgus loading of the knee predict anterior cruciate ligament injury risk in female athletes: a prospective study. Am J Sports Med 2005;33:492-501.

25 Howley ET, Bassett DR,Jr, Welch HG. Criteria for maximal oxygen uptake: review and commentary. Med Sci Sports Exerc 1995;27:1292-1301.

26 Impellizzeri FM, Rampinini E, Marcora SM. Physiological assessment of aerobic training in soccer. J Sports Sci 2005;23:583-592.

27 Kellmann M, Kallus KW. Recovery-stress questionnaire for athletes: User manual. Champaign, IL: Human Kinetics 2001.

28 Kempton T, Sirotic AC, Cameron M, et al. Match-related fatigue reduces physical and technical performance during elite rugby league match-play: a case study. J Sports Sci 2013.

29 Kentta G, Hassmen P. Overtraining and recovery. A conceptual model. Sports Med 1998;26:1-16.

30 Lian O, Engebretsen L, Ovrebo RV, et al. Characteristics of the leg extensors in male volleyball players with jumper's knee. Am J Sports Med 1996;24:380-385.

31 Lian OB, Engebretsen L, Bahr R. Prevalence of jumper's knee among elite athletes from different sports: a cross-sectional study. Am J Sports Med 2005;33:561-567.

32 Louw Q, Grimmer K, Vaughan C. Knee movement patterns of injured and uninjured adolescent basketball players when landing from a jump: a case-control study. BMC Musculoskelet Disord 2006;7:22.

33 McGuine TA, Greene JJ, Best T, et al. Balance as a predictor of ankle injuries in high school basketball players. Clin J Sport Med 2000;10:239-244.

34 McKay GD, Goldie PA, Payne WR, et al. Ankle injuries in basketball: injury rate and risk factors. Br J Sports Med 2001;35:103-108.

35 Mroczek D, Januszkiewicz A, Kawczynski AS, et al. Analysis of male volleyball players' motor activities during a top level match. J Strength Cond Res 2014;28:2297-2305.

36 Myer GD, Ford KR, Khoury J, et al. Biomechanics laboratory-based prediction algorithm to identify female athletes with high knee loads that increase risk of ACL injury. Br J Sports Med 2011;45:245-252.

37 Nederhof E, Brink MS, Lemmink KAPM. Reliability and validity of the Dutch Recovery Stress Questionnaire for athletes. International Journal of Sport Psychology 2008;39:301-311.

38 Olsen OE, Myklebust G, Engebretsen L, et al. Injury mechanisms for anterior cruciate ligament injuries in team handball: a systematic video analysis. Am J Sports Med 2004;32:1002-1012.

39 Pasanen K, Parkkari J, Kannus P, et al. Injury risk in female floorball: a prospective one-season follow-up. Scand J Med Sci Sports 2008;18:49-54.

40 Pasanen K, Parkkari J, Pasanen M, et al. Effect of a neuromuscular warm-up programme on muscle power, balance, speed and agility: a randomised controlled study. Br J Sports Med 2009;43:1073-1078.

41 Rampinini E, Coutts AJ, Castagna C, et al. Variation in top level soccer match performance. Int J Sports Med 2007;28:1018-1024.

42 Sheppard JM, Gabbett T, Taylor KL, et al. Development of a repeated-effort test for elite men's volleyball. Int J Sports Physiol Perform 2007;2:292-304.

43 Sheppard JM, Young WB. Agility literature review: classifications, training and testing. J Sports Sci 2006;24:919-932.

44 Terada M, Pietrosimone B, Gribble PA. Individuals with chronic ankle instability exhibit altered landing knee kinematics: potential link with the mechanism of loading for the anterior cruciate ligament. Clin Biomech (Bristol, Avon) 2014;29:1125-1130.

45 Van der Worp H, de Poel HJ, Diercks RL, et al. Jumper's knee or lander's knee? A systematic review of the relation between jump biomechanics and patellar tendinopathy. Int J Sports Med 2014;35:714-722.

46 Wang HK, Chen CH, Shiang TY, et al. Risk-factor analysis of high school basketball-player ankle injuries: a prospective controlled cohort study evaluating postural sway, ankle strength, and flexibility. Arch Phys Med Rehabil 2006;87:821-825.

47 Zwerver J, Bredeweg SW, van den Akker-Scheek I. Prevalence of Jumper's knee among nonelite athletes from different sports: a cross-sectional survey. Am J Sports Med 2011;39:1984-1988.