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Research article

Seasonal Variation in Objectively Assessed Physical Activity among Young Norwegian Talented Soccer Players: A Description of Daily Physical Activity Level

Stig A. Sæther ✉ and Nils P. Aspvik
Department of Sociology and Political science, Norwegian University of Science and Technology, Dragvoll, Trondheim, Norway

Abstract
'Practise makes perfect' is a well-known expression in most sports, including top-level soccer. However, a high training and match load increases the risk for injury, overtraining and burnout. With the use of accelerometers and a self-report questionnaire, the aim of this study was to describe talented players' physical activity (PA) level. Data were collected three times during the 2011 Norwegian Football season (March, June and October). The accelerometer output, counts·min^{-1} (counts per unit time registered), reports the daily PA-level for young talented soccer players. Results showed a stable PA-level across the season (March: 901.2 counts·min^{-1}, June: 854.9 counts·min^{-1}, October: 861.5 counts·min^{-1}). Furthermore, comparison of five different training sessions across the season showed that the PA-level ranged from 2435.8 to 3745.4 counts·min^{-1}. A one-way ANOVA showed no significant differences between the three measured weeks during the soccer season ($p \leq 0.814$). However, the training sessions in January had a significantly higher PA-level than those in June and October ($p \leq 0.001$). Based on these results, we discuss how potential implications of PA-level affect factors such as risk of injury, overtraining and burnout. We argue that player development must be seen as part of an overall picture in which club training and match load should be regarded as one of many variables influencing players' PA-level.

Key words: Talent, soccer, youth, physical activity, overload.

Introduction

'Practise makes perfect' is a well-known expression in most sports, including top-level soccer. The expression is often used as an argument for the assumption that the soccer players who have the highest and most effective training load will also achieve the highest skill and performance level (Ericsson et al., 1993). Studies illustrate that training load exposure increases from age 11 to 19 among elite youth soccer players (Baxter-Jones and Helms, 1996; Brito et al., 2012; Malina et al., 2000). Furthermore, McMillan and colleagues (2005) found that 18 year-old Scottish youth professional soccer players had an average training load (calculated as number of training hours per week) of 9.4 to 12.2 hours during a season.

In talent development, the monitoring of training and match load is important. Talented soccer players are often identified at a young age and are given the opportunity to train and compete on different teams, including a higher-level team within their club, a regional team or a national team. Furthermore, the label "soccer talent" often comes with high expectations from both the player and the players' environment (i.e., the club and coach). For the most talented players, the pressure to be successful is felt at an early age (Hill, 2013). Being labelled a soccer talent often implies playing in more matches and participating in fewer training sessions during a week (McMillan et al., 2005). As the intensity during a match is higher than in training sessions (Capranica et al., 2001), it is reasonable to assume that the physical activity (PA) level for talented players could be higher compared to players not identified as talented. A potential downside in the increased number of matches is the increased risk of injury, i.e. overuse (Brito et al., 2012). Le Gall and colleagues (2006) found older players to be injured more often during matches, while younger (U14) players incurred more injuries in training and sustained more growth-related overuse injuries. The injury risk is found to be significantly higher in soccer compared to other sports (Baxter-Jones and Helms, 1996). Furthermore, the pressure to be successful could lead to a potential lack of motivation and burnout. Hill (2013) found that one out of four 13–16 year-old players selected to an English professional club experienced symptoms of burnout at least once in the players career.

From a talent development perspective, it is important to investigate talented players' PA-level. Physical activity is defined as any bodily movement produced by skeletal muscles resulting in energy expenditure (Caspersen et al., 1985). Researchers previously attempted to describe a normal training week for both professional (Bangsbo et al., 2006) and youth soccer players (Akubat et al., 2012; Wrigley et al., 2012). These studies have, however, only focused on club related PA-load (training, match) with different approaches and measurements, including how both external (Rampinini et al., 2007; Hill-Haas et al., 2009; Brink et al., 2010) and internal (Akubat et al., 2012) training and match load can influence players' physiological response. To understand talented players' "total" PA-level, one could argue that it is important to also include activity outside the club. Several approaches have been used in an attempt to understand athletes' training and match load across a range of sports, including soccer (Wrigley et al., 2012). However, when reviewing the literature, studies using objective measurements to assess daily physical activity in talented soccer players were not discovered.

In this study, the focus is on the players daily PA-level. The use of accelerometers to assess physical activi-

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ty provides an opportunity to improve understanding about talented soccer players' PA-level. The aims of this study are: (1) to describe talented players' mean daily PA-level during three weeks in different periods of the season (2) to describe talented players' PA level in five training sessions within the same three weeks.

Methods

Participants and setting

Participants included 23 male youth soccer players (age = 17.8 ± 1.3yrs) who represented a premier level club in Norway. Data were collected from March 2011 through October 2011, with physical activity assessments during three weeks of the year. The three weeks ranged from the 18th to 25th of March, the 10th to 17th of June and the 14th to 21st of October. Average daily monitoring time was 12.5±1.1 hours, ranging from 12.64±1.02 in March (n = 14), 12.64 ± 2.14 in June (n = 13) and 12.16 ± 0.30 in October (n = 13).

Informed written consent was obtained from players, parents of under-age players and coaches. The study (ethics clearance) was in accordance and approved by the Norwegian Social Science Data Services.

Objective measure of daily physical activity

ActiGraph GT3X accelerometers (Manufacturing Technology Incorporated, Fort Walton Beach, FL) were used to obtain an objective assessment of physical activity. ActiGraph GT3X are small (3.8 x 3.7 x 1.8 cm), lightweight (27 g) activity monitors that measure and record time varying accelerations ranging in magnitude from approximately 0.05 to 2.5 G's. The accelerometer output is digitised by a twelve-bit Analog to Digital Convertor (ADC) at a rate of thirty times per second (30 Hz). Once digitised, the signal passes through a digital filter that band-limits the accelerometer to the frequency range of 0.25 to 2.5 Hz. This frequency range has been carefully chosen to detect normal human motion and to reject changing accelerations within the pass band. Each sample was summed over a user specified interval of time called an "epoch". In this study a 60-second epoch was used.

Using a reader interface unit connected to a computer, the recorded data were downloaded and analysed using the software supplied with the unit. Previously studies have reported a highly significant correlation between physical activity recorded by the accelerometer and energy expenditure assessed by indirect calorimetry; in addition, there is a high degree of inter-instrument reliability (Janz et al., 1995). It has been reported that during laboratory exercise there is a high correlation (r = 0.86) between accelerometer recordings and energy expenditure (Trost et al., 1998); however, others have questioned whether this level of precision can be reproduced during everyday activities (Harro and Riddoch, 2000).

Soccer players self-reported PA-level

Players additionally completed a questionnaire during the sample period (October). The accelerometer data and two questions from the questionnaire were used to obtain an overall, both objective and subjective, understanding of the players PA-level. The items used in this article include: 1) "The physiological and psychological training and match load have been very high this season," and 2) "The physiological and psychological training and match load have varied a lot throughout this season." Both questions have a categorical Likert scale from 1 (agree) to 7 (disagree).

Protocol

Data were collected three times during the 2011 Norwegian Football season (March, June and October). Before each sample period, the activity monitors were tested. For the present study, the epoch duration or sampling period was set at one (1) minute and the output was expressed as counts per minute (counts·min^{-1}). The accelerometer was firmly placed and adjusted on the players' waist by an elastic belt over the right hip. The players were instructed to wear the monitor for seven days, from the time they got out of bed in the morning until they went to bed at night (except during showering and swimming activities).

Data reduction

Using a range of methods, measurements of activity with the ActiGraph accelerometers have been well validated in both children and adolescents (Brage et al., 2003; Corder et al., 2005). Players failing to provide our wear-time-validation (WTV) (a minimum of four separate days of ten hours of valid recording (Hansen, 2013)) were excluded from the study. The WTV included 14 (61%) players in March, 13 (57%) in June and 13 (57%) in October.

Uniaxial data (axis one) are used to estimate mean physical activity per day (counts·min^{-1}). Axis one is a measurement of vertical movement, meaning that information from other dimensions was not taken into account. Mean physical activity was considered to be the total accelerometer counts per valid minute of recording. Mean physical activity and time (percent) spent in different activity intensities in training sessions was also estimated. Published cut-offs for different intensity levels in youth vary substantially between studies. Moderate-to-vigorous-physical-activity (MVPA) was defined as >1952 counts·min^{-1} (Freedson et al., 1998). In comparison, The Norwegian Directorate of Health defined 2000 counts·min^{-1} as MVPA (The Norwegian Directorate of Health, 2008). This is broadly equivalent to walking at 4 km·h^{-1} (Andersen et al., 2006; Ekelund et al., 2004; Kolle et al., 2009). The cut-off for vigorous PA was 5725 counts·min^{-1} and very vigorous PA was 9500 counts·min^{-1} (Freedson et al., 1998).

Statistical analysis

In the analyses of accelerometer data, the Mahuffe Processing Software (version 1.9.0.3) and the Actilife Analysis Software (version 6.4.3) to process activity data (WTV, MVPA & counts·min^{-1}) were used. One-way ANOVA were performed on the accelerometer scores to test for differences between the three measured weeks, and for differences between the five measured training sessions. Statistical Package for the Social Sciences (PASW statistics, version 18.0) for Windows was used to

Table 1. Physical activity level in five soccer trainings. Percent in intensity zones and counts·min^{-1}.

Training	Percent in intensity zones						Counts·min^{-1}
	Sedentary 0-99	Light 100-1999	Moderate 2000-5724	Vigorous 5725-9499	Very vigorous 9500 →	MVPA* 2000 →	
T1 March 18	7.1	24.4	43.3	22.8	2.4	68.5	3745.4 ± 646.0
T2 March 25	8.4	24.5	41.3	24.1	1.8	67.2	3663.8 ± 465.0
T3 June 10	13.7	30.2	49.2	6.8	0.1	56.1	2339.2 ± 808.8
T4 June 17	16.1	34.7	38.4	10.1	0.7	49.1	2435.8 ± 689.9
T5 October 21	7.2	32.1	46.2	11.5	2.9	60.6	3069.7 ± 783.4
Mean	10.5	29.2	43.7	15.1	1.6	60.3	3119.9 ± 883.4

* MVPA = the summation of moderate, vigorous and very vigorous intensity.

analyse the data. A *P* value ≤0.05 was required to declare statistical significance.

Results

The players' mean (SD, [95 % CI]) daily physical activity was 901.2 (170.4, [802.8, 996.6]) counts·min^{-1} in March, whereas the corresponding values were 854.9 (210.2, [728.0, 982]) in June and 861.5 (227.8, [723.9, 999.2]) in October. There were no significant ($p < 0.814$) differences in mean daily physical activity level between the three different measured weeks.

Physical activity in training sessions

The distribution of players' time spent in sedentary, light, moderate, vigorous and very vigorous PA during five training sessions is displayed in Table 1. Furthermore, counts per minute are used as a measurement of the players' mean physical activity.

In this study, talented youth soccer players averaged between 49.1 to 68.5% of MVPA during training sessions. Ten per cent of the training sessions were sedentary activity. The sedentary activity occurred during breaks, when coaches were giving instructions and players were waiting for a turn. Thirty per cent was in light intensity activity, 43.7% in moderate intensity activity, 15.1% in vigorous intensity activity and 1.6% in very vigorous intensity activity.

Counts·min^{-1} in the two training sessions in March were significantly higher than the two training sessions in June ($p \leq 0.001$). There were no significant differences between March and October, nor June and October (Table 2).

Self-report training and match load

At the end of the season (October), the players responded to a questionnaire regarding their total training and match load. Approximately 60% of players experienced a high match load and physiological and psychological training during the season. However, 40% reported a large variation in physiological and psychological training and match load throughout the season.

Discussion

In European soccer, it is common to identify talented soccer players at a young age. According to Malina and colleagues (2000) and McMillan and colleagues (2005) talented players will experience a large training and match load. This corresponds with Ericsson's (1993) perspective on the relationship between training load and skill level. When PA-level is assessed, one has to consider both the club- and the non-club organised physical activity (Capranica et al., 2001). The benefit of studying the PA-level among talented soccer players over an entire week provides an opportunity to achieve an overall picture. Using different measures, earlier studies have described a normal training and match week within a club for both professional and youth players (Akubat et al., 2012; Bangsbo et al., 2006; Wrigley et al., 2012). However, neither of these studies used the ActiGraph accelerometer.

Without any comparable studies using accelerometers (with the same output data) on youth elite players, there is no reference value to indicate whether or not the players in our study have a high PA-level. However, in a study of 15 year-old Norwegian boys, Kolle and colleagues (2009) found their mean PA-level to be 542 counts·min^{-1} (SD = 199). Due to a high correlation (r = 0.86) between accelerometer recordings and energy expenditure in an earlier study (Trost et al., 1998), the high PA-level in our study, compared to 15 year-old Norwegian boys, probably indicates a high daily energy expenditure for the talented soccer players.

In March, June and October, the players' mean daily PA-level was 901.2, 854.9 and 861.5 counts·min^{-1}, with no significant difference reported between the weeks. However, the PA-level in training sessions (Table 1) ranged from 2435.8 to 3745.4 counts·min^{-1}, and showed a significant difference between the training sessions in March and June ($p \leq 0.001$) (Table 2). This could

Table 2. One-way ANOVA test of variance between five soccer trainings in March, June and October.

	Soccer trainings					ANOVA P	#Significant between soccer trainings
	1 March 18th (95 % CI) (n = 15)	2 March 25th (95 % CI) (n = 16)	3 June 10th (95 % CI) (n = 11)	4 June 17th (95 % CI) (n = 13)	5 October 21st (95 % CI) (n = 12)		
Axis 1 counts·min^{-1}	3745.4 (3388, 4103)	3663.8 (3416, 3912)	2339.2 (1796, 2883)	2435.8 (2019, 2853)	3069.7 (2572, 3567)	≤ .001	1 & 2 > 3 & 4, 5

CI = Confidence interval; Axis 1 counts·min^{-1} = Total counts/minutes; ANOVA = Analysis of variance. # Significant contrast, $p \leq .05$.

suggest that the players are adjusting their daily physical activity level (club- versus non-club PA), in order to balance the relationship between physical activity and recovery. MVPA averaged between 49.1 and 68.5% during training sessions and corresponded with the seasonal differences; with the lowest MVPA in the mid-season and the highest MVPA in the pre-season. This could, of course, be a result of different tasks and goals (i.e., different tactical, technical and physical elements) throughout the season.

Knowing that there are individual differences among young talented soccer players (Brito et al., 2012; McMillan et al., 2005), one could highlight the importance of focusing on players' individual PA-level. Two important questions for clubs and coaches working with young talented soccer players should be: 1) what is his/her PA-level? and 2) what could and should the PA-level for him/her be, depending on the player's position, physical fitness level, motivation, performance level, etc.? This is important knowledge to stimulate players' development and to reduce their risk of physical overload (Brenner, 2007), psychological burnout (Hill, 2013) and risk of injury (Brito et al., 2012).

Limitations and future directions

The limitations of the study should be recognised. We used uniaxial data to analyse players' PA-level. However, based on the activity characteristics of soccer, we would recommend future studies use triaxial accelerometers. The study employed a small sample size and included players from only one soccer club, which makes it difficult to generalise the findings. Further, there are no comparable studies using accelerometer in youth elite players. Nevertheless, the results indicate that the PA-level, including club and non-club activity, for these players is high compared to Norwegian 15 year-old boys (Kolle et al., 2009). Future studies should attempt to establish more knowledge regarding individual adjustments of young talented soccer players PA-level, including the players' physical fitness, risk of injury, overtraining and burnout.

Conclusion

Compared to a population-based study of Norwegian 15 year-old boys (Kolle et al., 2009), our results imply a high and stable daily PA-level for young talented soccer players throughout a season. Even so, results from the five training sessions in our study, indicate a variance in PA-levels; the training sessions in January had a significantly higher PA-level than those of June and October. Our results also show that approximately 60% of the players reported high physiological and psychological training and match load during the season. Indeed, we have argued that player development must be seen in an overall picture where the club related training and match load should be regarded as one of many variables influencing players' PA-level. From a talent development perspective, soccer talents ranging in age from 15 to 18 years are in a critical development period. Since results show that over 80% of players in Norwegian youth national teams want to attend a sport educational program in high school (Sæther, 2013), it is reasonable to assume that these players have a high daily level of physical activity and sport participation. In this regard, we recommend both clubs and coaches supervise each player's daily PA-level, in order to reduce a potential overload. As an example, it is important for the club and coach to cooperate with the players' school. We would highlight that the most important and effective way to prevent physiological and psychological overload is to educate both coaches and players. Both monitoring the PA-level and making individual adjustments should be regarded as important parts of the talent development process.

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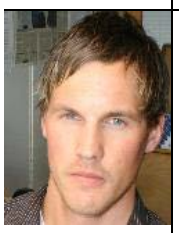
Key points

- It is well established that to achieve a high performance level in sport, one must implement a high training and match load in childhood and youth.
- With the use of accelerometers and a self-reported questionnaire, the aim of this study was to describe talented players' total physical activity (PA) load.
- These results indicate that young talented soccer players must overcome large doses of PA on a weekly basis, exposing them to a high risk of injury, overtraining and burnout.

AUTHORS BIOGRAPHY

Stig Arve SÆTHER
Employment
Assistant professor in sports science. Norwegian University of Science and Technology, Trondheim, Norway.
Degrees
BSc, MSc in sports science
Research interests
Talent development, youth sport
E-mail: stigarve@svt.ntnu.no



Nils Petter ASPVIK
Employment
Phd scholar in sports science. Norwegian University of Science and Technology, Trondheim, Norway.
Degrees
BSc, MSc in sports science
Research interests
Physical activity in everyday-life
E-mail: nils.petter.aspvik@svt.ntnu.no

✉ **Stig Arve Sæther**
Department of Sociology and Political science, Norwegian University of Science and Technology, Dragvoll, 7491 Trondheim, Norway