Simen Røhjell Haugan

The Effect of Sleep on Physical Performance in Male Elite Soccer Players

A Pilot Prospective Cohort Study

Master's thesis in Physical Activity and Health - Movement Science
Supervisor: Ulrik Wisløff
Co-supervisor: Arnt Erik Tjønna

May 2021

Master's thesis

NTNU
Norwegian University of Science and Technology
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NTNU
Kunnskap for en bedre verden

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Trondheim, May 18th 2021
Simen Røhjell Haugan

Effect of **Sleep** on **Physical Performance** in Male Elite **Soccer** Players

By Simen R. Haugan

Soccer is a versatile and physically demanding sport. Sleep is known to have an impact on several physical performance related outcomes. Due to limited technology, previous research has mostly investigated sleep loss, not sleep quality, further assessing physical performance in standardised tests, not real-life scenarios.

Background

Sleep Quality

- Sleep is important, especially for athletes, yet many reportedly sleep insufficient
- Likely during deep sleep, the body regenerates cells necessary for recovery and performance
- Effect of natural differences in sleep on soccer players not investigated, only interventions

Physical Performance

- Peak 5-min high-intensity run meters is a good measure of physical performance in soccer
- There are conflicting results regarding the impact of sleep on physical performance
- Standardized tests on athletes might not be representative of match play in soccer

Methods

- Pilot prospective cohort study conducted during the entire 2020 soccer season
- Assessed male elite soccer players from Ranheim IL (n=11)
- Somnofy measured sleep quality accurately through radar technology every night

- ZXY Sport Tracking measured peak 5-min high-intensity run meters (19.8-25.2 km/h) on trainings and home series matches
- Investigated the effect of varying deep sleep on peak 5-minute high-intensity run meters the following day

Results

showed a tendency towards a negative association between deep sleep and peak high-intensity run

For every 1 minute increase in deep sleep..

Peak high-intensity run was reduced with .110 meters on average

Conclusion

The study was conducted with a low sample size and lack of significance. Larger studies are warranted

References: 1,12,13,18-20,24,27,28

Abstract

Background: Soccer is considered the most popular sport in the world, where the outcome of a match depends on a variety of factors. Severe sleep loss is established to have negative effects on several endurance related performance outcomes. However, sleep quality has not been investigated in relation to soccer specific physical performance (PP). **Purpose:** To investigate effect of deep sleep (DS) on peak 5-minute high intensity run (peak HIR) – and how pre-sleep protein supplement is affecting the association between DS and peak HIR. Lastly, to investigate the effect of effort on respiratory rate per minute (RR). **Material and methods:** A pilot prospective cohort study including 11 male elite soccer players (mean ± SD age 23.8 ± 2.4 years, height 185.9 ± 5.1 cm, body mass 80.6 ± 6.1 kg) entire 2020 soccer season, goalkeepers excluded. Peak HIR (19.8-25.2 km/h), and effort measured using ZXY Sport Tracking during training sessions and home series matches. Peak 5-minute periods calculated using a rolling 5-minute window for trainings and home series matches. Minutes of DS, and RR measured using the non-invasive sleep monitor Somnofy every night, gathering data autonomously. Smartfish used in the assessment of pre-sleep protein supplement. Linear mixed model analysis applied for all analyzed effects. Interaction test applied for difference in protein supplement. **Results:** DS was negatively associated with peak HIR (95% CI [-.306, .084]). Protein supplementation showed no difference between dosages (p.=623) and RR was unaffected by effort (95 % CI [-.000007, .000046]). **Conclusion:** The study was conducted with a small sample size and there was a lack of significance. However, results showed a tendency towards peak HIR being negatively affected by increased DS. Targeting sport specific PP outcomes in real-life scenarios may be of importance. Larger studies are warranted.

Key words: Sleep quality, deep sleep, physical performance, high intensity run, soccer

1. Background

1.1 Introduction

Soccer is enjoyed by women and man of all ages, and is considered the most popular sport in the world [1]. The sport is complex, where a variety of different factors interplay [1]. Each player on a team has to be physically capable of performing demanding tasks, and mentally able to "read", understand and interact with teammates and opponent players movements [1–3]. The distance soccer players cover during a match varies but is normally around 11 kilometers per game for elite players. This includes walking, jogging and sprints, as well as larger distances covered by high intensity run (HIR) [1]. The sport is mainly dominated by aerobic work, although requires anaerobic capacity in several in-game situations e.g., tackles, sprints and duels. Soccer has proven to be one of the most demanding sports in terms of versatility. Depending on specific playing position and role within a team, soccer players must possess several physical attributes as shown in Figure 1 [1,4,5].

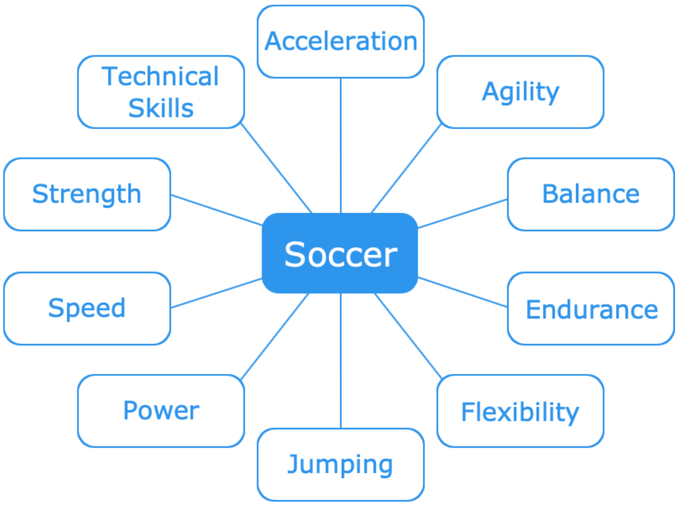

Figure 1. Physical attributes of soccer players (1,4).

Some physical attributes can be measured as physical performance (PP), which is a common practice for teams to optimize performance and prevent injuries [6–10]. Today's technology such as ZXY Sport Tracking (ZXY) makes it possible to objectively measure small movements with high accuracy. This results in measurements of total effort a player performs (Appendix 1), as well as accelerations, sprints and HIR [4,7]. There are positional differences in soccer, and physical demands of match play are different for wingbacks compared to central midfielders [6,7]. According to Malone et al. (2018), HIR is required for soccer players to gain advantages in offensive and defensive situations, possibly making HIR the most common variable between playing positions. Other variables such as sprints and accelerations may vary to a larger extent between positions compared to HIR [8,11]. Krustrup et al. (2003 and 2005) suggested that HIR is a valid measure of PP in soccer, and point to specially peak 5-minute periods of HIR (peak HIR) as representing the most intense and demanding period of a soccer match [12,13]. These periods are naturally found to be greater in the first compared to the second half of match play due to fatigue [6,9–11,14,15].

Sleep prior to competition or matches is essential, yet often difficult for athletes [16]. General recommendations for adults is approximately 8 hours of sleep per night [17], while some suggests athletes need to sleep between 9 and 10 hours per night [18,19]. Despite need of more sleep, previous studies report athletes sleeping less compared to non-athletes [16,18,20]. The function of sleep is not fully understood, and there exists individual differences regarding needs of sleep. However, advances in research provide new information steadily [19,21]. For instance, how good one sleeps is not just number of hours slept per night. It depends on sleep quality (SQ) variables e.g., time in different sleep stages, maintaining circadian rhythm, how many times per night one wakes up, movement during sleep and respiratory rate per minute (RR). The National Sleep Foundation states that the term SQ has not yet been defined, other than that it is based on underlying identifiable variables of sleep [22]. All presented variables can be affected by external factors e.g., room temperature, stress and noise [23]. A device named Somnofy has recently made it possible to objectively monitor all aforementioned variables effortlessly through radar technology, with higher accuracy than previous objective and subjective measurements, e.g. watches, apps and questionnaires [24,25]. Somnofy allocates monitored sleep into different stages experienced during a night [26]. These sleep stages can be divided into three main categories (Figure 2). The first being light sleep, where heartrate and RR decreases, muscles begin to relax and body temperature drops. Deep sleep (DS) is the second stage, where it is likely that the body regenerates cells and tissue, and repair and growth occurs [19,27,28]. DS typically represents 20-25% of total sleep [23]. Rapid eye movement (REM) is the last stage, where the body begins to increase heartrate and RR [29]. The daily sleep-wake cycle is intertwined with the circadian rhythm. Simplified, circadian rhythm refers to the body's natural production cycle of the hormones melatonin and cortisol, which makes one feel sleepy and awake respectively [16,30,31]. SQ may be reduced if one sleeps while hormone levels are "out of sync", typically referred to as jetlag [16,32]. The sleep-wake cycle is mainly affected by daylight [5,32], but also factors such as alcohol, performing demanding tasks requiring a high level of concentration, taking excessive naps during the day, varying the time one wakes up, caffeine or high intensity workouts right before bedtime [5,18,33].

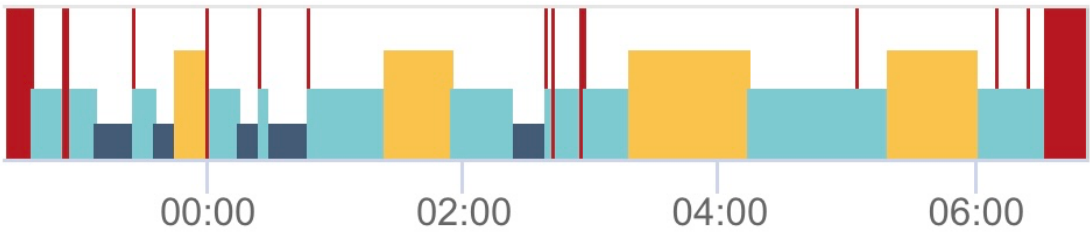

Figure 2. Hypnogram. Red: awake, light blue: light sleep, dark blue: deep sleep, yellow: rapid eye movement (REM) sleep. Source: Cutout from the Somnofy Research app.

Research leads to believe that sleep may have an impact on athletes PP [2,5,19]. A study from Fullagar et al. (2015) stated that maximal physical efforts could be maintained, as athletes experienced three hours of sleep loss per night. They further stated that sleep loss mostly affected sport specific performance, in agreement with Bonnar et al. (2018) [18,19]. In contrary, a review conducted by Simpson et al. (2017) found that reducing sleep to 4-5 hours per night negatively affected factors such as speed, endurance and strength measured with standardized tests - and not only sport-specific performance [24]. Correspondingly, several other studies stated that everything from 3 hours of total sleep per night to 64 hours of total sleep deprivation could lead to reduced PP [16,30]. Furthermore, cognitive function may be affected by various lengths of sleep loss, e.g., get slower, less accurate, decrease ability to asses risks, reduce motivation and spacial awareness [31–33]. This may impact players PP in soccer, as it has shown to increase total distance covered in matches, likely due to poor tactical decisions [2]. Moreover, it has been suggested that increased sleep is a sign of increased need of recovery, as one study stated that reduced PP was associated with increased sleep duration in athletes [20]. It is further discovered that the opposite effect of sleep loss occurs in instances of extended sleep [34]. There is an absence of clear definitions regarding sleep [22], which is reflected in the wide use of the term sleep loss among authors in everything from a delayed sleep onset to several days of total sleep deprivation [16]. PP outcomes have been measured differently across studies as well, which creates difficulties in interpretation and comparisons of results. Additionally, few studies have looked specifically at soccer, which leads to necessity of sport specific PP outcomes, measured in "real-life" scenarios, not commonly used standardized tests [19].

An athlete may compete once a week or more [35], and in order to continuously physically perform at a high level, good recovery is a key component. According to Snijders et al. (2019), sleep is considered to be one of the most important recovery methods [36]. Heavy training sessions and matches including sprints, accelerations, jumps and changes of direction lead to muscle damage due to elicit lengthening and stretching of muscles [5,33,35]. Likely during DS, the body breaks down cells, which is required for future repair and growth [19,27,28]. Insufficient sleep may therefor result in muscle degradation and reduced PP [19]. Reduced recovery may not only affect athletes PP, it could furthermore increase the risk of injury [5,24,31,33,37,38], as illustrated in Figure 3. Soccer being a contact sport increases the risk further, and a high injury rate can be problematic for soccer teams in terms of performance and costs [37]. This is further accentuated if the match schedule is hectic, as an increase in matches from 1 to 2 per week could increase the risk of injury sixfold [33,37].

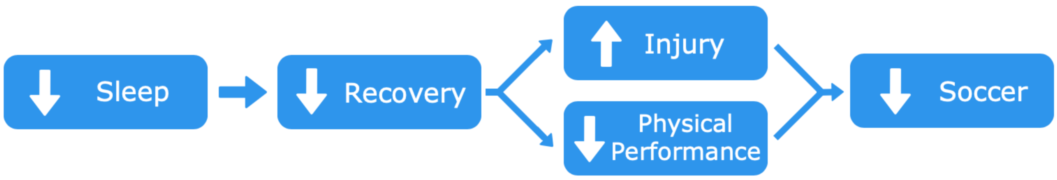

Figure 3: Possible relationship between sleep, recovery, injury, physical performance, and soccer (19,28,36,37). ↑: Increase, ↓: Decrease.

Pre-sleep protein consumption is speculated to further maximize recovery [35,36,39–41] and improve SQ [27] - thereby potentially increase PP in soccer, as illustrated in Figure 4. Supplements containing protein may have beneficial effects on the body's protein synthesis, which may be necessary for restoring impaired muscle function and damaged muscle fibers from soccer trainings and matches [35,40,42]. It is generally recommended to ingest protein supplements after exercise to aid recovery [35]. For building or maintaining muscle mass it is largely agreed that healthy, exercising individuals must consume approximately 1.5-2.0 grams of protein per kilogram body weight per day [35,41]. A systematic review conducted by Reis et al. (2021) found evidence of positive effects on protein synthetic response when ingesting 20-40g of protein pre-sleep, among young adults performing resistance training [39,41]. The rationale behind ingesting additional protein supplementation approximately 30 minutes before sleep was to increase muscle protein synthesis rate which occurs during nights [5,35,36]. Existing research on pre-sleep protein supplementation have largely focused on muscle damage and general recovery [40,41], not on its effect on SQ and PP. A protein supplement named Smartfish has recently been released, and a study conducted using the supplement found evidence of possible benefits in reducing muscle soreness and ability to maintain muscle function after eccentric exercise in rugby players [43]. Equally, an experimental study using the same supplement on soccer players pre-sleep also reduced muscle soreness and increased recovery [42]. However, there is a lack of information regarding the effect on SQ and PP in soccer.

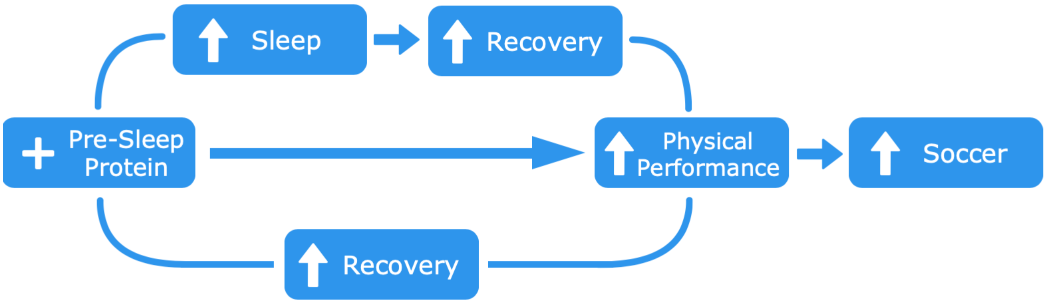

Figure 4: Possible relationships between pre-sleep protein supplementation, sleep, recovery, physical performance and soccer (27,35,36,39,40,42,43). +: plus, ↑: Improvement.

Another aspect of sleep which may be associated with recovery is RR. It has not been researched extensively during sleep, even though it is a fundamental vital sign similar to heart rate (HR) and has practical applications in exercise. During exercise, RR can be used as a marker of fatigue or performance. Similar to HR, elevated RR while awake is an indication of exhaustion, but what regulates RR during sleep has not been thoroughly investigated [44]. Current knowledge states that RR decreases during sleep and alternates during REM sleep [29]. Some have further suggested that an increase in RR at night might indicate internal or external stress [23]. Nicolò et al. (2020) stated that further research regarding RR monitoring is needed [44].

Numerous studies have investigated the association between sleep and PP, with different approaches. Sleep loss interventions varying from delayed sleep onset to several days of total sleep deprivation have largely been used [16], with conflicting results [19,20,24,30]. Studies have likely not focused on SQ variables, e.g., DS and RR, due to technology limitations. Use of new technology like Somnofy enables exploration of said SQ variables [26]. It is likely that reduction in total sleep will lead to similar effects as reduction in DS, due to DS being hypothesized as the determining variable in the relation between sleep and PP, thereby making comparisons to previously conducted research possible [19,20,27,28]. The association between sleep and different PP outcomes has mostly been assessed with standardized tests and not in sport specific settings in a real-life scenario, and little research has been conducted regarding soccer. Bonnar et al. (2018) suggested using sport specific PP outcomes, e.g., peak HIR, as a better approach than general endurance performance measures from standardized tests [19]. Further on, the impact of pre-sleep protein consumption on muscle soreness and recovery seems well established [35,39–41], but its impact on SQ and PP in soccer is still uncertain. Additionally, the SQ variable RR could provide useful indications of physical status, but research on the subject is limited [44]. To summarize, new research conducted in the field of soccer, using different methodology and equipment seems warranted.

1.1.1 The aim of the study

The main aim of the study is to investigate the effect of SQ variable DS on next day soccer specific PP outcome peak HIR, in male elite soccer players. As secondary aims, the first is to investigate whether the association between DS and peak HIR is affected by pre-sleep protein supplementation. Lastly, the study aims to investigate the effect of PP outcome effort performed on training sessions and matches on SQ variable RR the following night. The hypothesis is that DS will affect peak HIR and that pre-sleep protein supplementation will have an effect on the association. Furthermore, effort is suspected to have an effect on RR.

2. Methods

Reporting of present research, when applicable, adhered to the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [45].

2.1 Study design and setting

The present study was conducted as a pilot prospective cohort study by master's students in Physical Activity and Health at Extra Arena, home stadium of Ranheim Football Club (Ranheim FC). PP and SQ data were objectively obtained from male elite soccer players during the 2020 Norwegian first division soccer season, before, during and after trainings and home series matches (Figure 5).

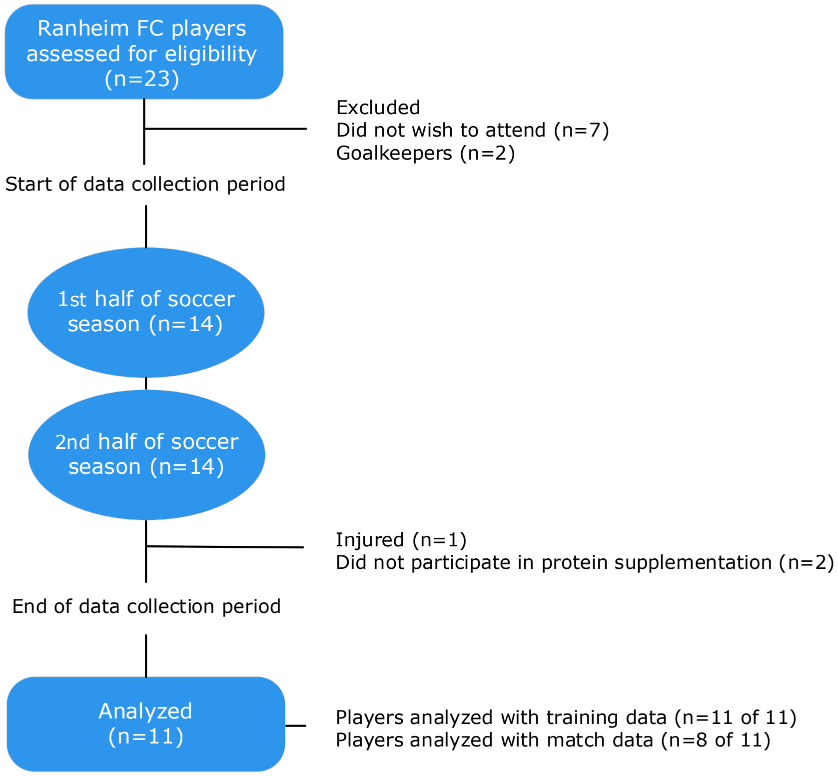

Figure 5. Flow chart of study design. FC: Footbal Club, n= sample size, 1st: first, 2nd: second.

The study progressed as illustrated in Figure 6: The data collection period was divided into first and second half of soccer season. The first half of the season (July to September 2020) players PP data was collected objectively using ZXY every training and home series match. SQ was measured using Somnofy every night. Simultaneously players were given one Smartfish Recharge High Protein (Smartfish) supplement to drink after each training and home series match. The second half of the season (September to December 2020) proceeded as the first, except players were given an additional protein supplement to drink pre-sleep every night.

Figure 6. Timeframe of the present study. NSD: Norwegian Centre for Research Data, REC: Regional Committees for Medical Research Ethics.

2.2 Study population

Male elite soccer players from Ranheim FC were included in the present study. Ranheim FC is a soccer team in the second highest division in Norway and are based in Trondheim, a city in Trøndelag county. All positions were included, except goalkeepers. All available players were approached with an information sheet and an invitation to participate in the study by the teams physical coach, who had an affiliation with the Norwegian University of Science and Technology (NTNU). Players who attended the study gave a written consent to participate.

2.3 Measurements and methods

2.3.1 Physical performance measured with ZXY Sport Tracking System

Objectively measured PP using ZXY Sport Tracking System (ZXY Sport Tracking AS; ChyronHego Nasdaq, Trondheim, Norway) was the primary outcome variable. ZXY is a sport tracking system that measures in meters variables as; total distance covered, walk, jog, sprint, HIR, as well as per minute; number of sprints, accelerations and decelerations [4,46,47], in addition to an overall score of effort in an arbitrary unit (Appendix 1). ZXY uses a small transponder (ZXY GEO transponder, 90 x 45 x 15mm, Figure 7), that registers movement in all three axes and samples at 10Hz (Appendix 2). ZXY has been validated by Fédération Internationale de Football Association (FIFA, Appendix 3). All players on Ranheim FC used ZXY both at trainings and home series matches, which required players to wear a specifically designed vest containing the transponder (Figure 8).

Figure 7. ZXY Sport Tracking transponder. FIFA: Fédération Internationale de Football Association, GNSS: Global Navigation Satellite System, g: gram, °C: degrees Celsius. Source: Appendix 2.

All standardized training sessions (2, 3 and 4 days before matches, with 7 days between matches), as those achieved physical demands somewhat close to match play, and home series matches were included in the dataset. Peak HIR was used as measure of PP outcome for the primary aim. HIR was set to all meters covered with speed between 19.8 and 25.2 km/h (Appendix 1), which is a velocity threshold in accordance with previous research [6,46,47]. To identify peak HIR for each player, a calculation using mean 1-minute numbers for HIR supplied by ZXY was performed. The mean 1-minute numbers were sorted in rolling 5-minute periods (1-5, 2-6, 3-7 etc.) to identify the absolute peak 5-minute period. The peak period represented the highest value of HIR, which previously has been used to describe the most intense period of match play [14,46]. Effort was used as an exposure measure of PP for the last secondary aim. It was a score accumulated by all movements a player made, including those too small to be categorized as jog, acceleration etc., which was used as a summary variable of the total load a player endured during a soccer training or match (Appendix 1). Players who played less than 45 minutes of matches were excluded from the dataset, as well as players on trainings who did self-organized activities.

Figure 8. ZXY Sport Tracking vest. Source: Aftenposten 10.05.2019 «Her begynner Ranheim med opplegget Horneland ikke vil ha» & Ranheimfotball on Instagram.

2.3.2 Sleep variables measured with Somnofy

Sleep variables were measured objectively using Somnofy (VitalThings AS, Norway) and was considered the exposure of the primary outcome variable. Somnofy has just recently been validated against polysomnography, the gold standard in the field of sleep research, where it showed a substantial agreement [27,31,48]. Somnofy is a non-invasive sleep monitor which uses radar technology to monitor respiratory events as well as movements, and samples at about 24 GHz. The device automatically classifies sleep stages (awake, light, deep and REM) and measures environmental factors in the room such as humidity, air quality, room temperature, noise level and light. With the use of all factors measured, it automatically creates a summary of SQ each day. A cutoff distance for measuring can be set, typically to the centerline of the bed, which is practical if the bed is shared with a partner. If one exceeds the set line, Somnofy will no longer gather data (Figure 9). The device is after initial setup completely autonomous. It recognizes when a person enters the room and automatically starts a new session, which ends when the person leaves for an extended period of time [26].

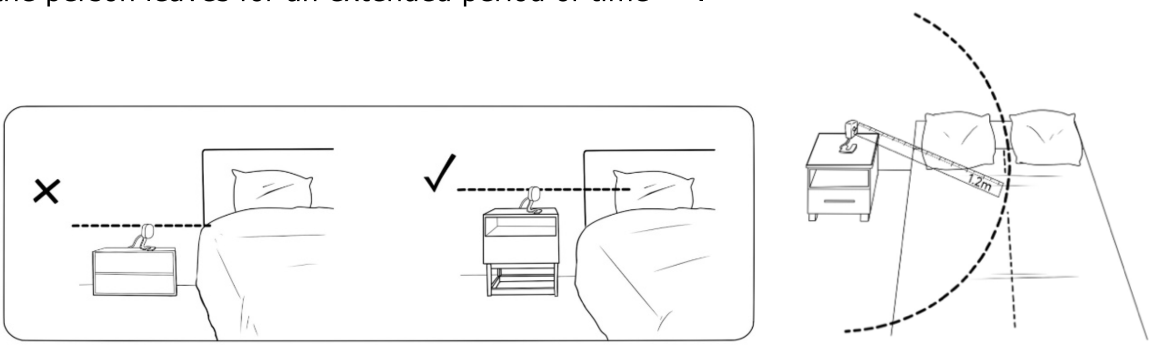

Figure 9. Somnofy placement in the bedroom and example of cutoff. Source: Somnofy.com/installation.

A grid network was created, connecting all player accounts under the umbrella of a main account, in order to access each players sleep data. Each monitor was linked to separate accounts prior to handout. Use of Somnofy was supported with written instructions (Appendix 4) and corresponding app (Figure 10). The data from each session was automatically stored by Somnofy, who generated one complete data sheet including all variables for all players after completion of data collection period. Nights with several individual sessions per player (which happened if the player exceeded the set monitor cutoff distance multiple times) were merged to obtain one sleep session per night. Sessions <4 hours of total sleep time, where Somnofy was unable to identify and categorize a large proportion of sleep, was excluded from the dataset, as recommended by Somnofy. Minutes of DS was used as an exposure measure of SQ for the primary aim, and RR as outcome measure for the last secondary aim. Only RR from light- and DS were used, as RR during REM sleep is irregular [29].

Figure 10. Somnofy device and corresponding app. Source: somnofy.com/how-it-works & somnofy.com/research.

2.3.3 Pre-sleep protein supplementation

Smartfish Recharge High Protein (Smartfish AS, Oslo, Norway) was used as protein supplement in the present study and acted as an exposure to the association between DS and peak HIR, for the first secondary aim. Smartfish is a ready to drink supplement that comes in 200ml cartons (Figure 11, Appendix 5). It was stored in room temperature as recommended by Smartfish AS. For the first half of soccer season (July to September 2020) the players ingested one protein supplement after each training and home series match. During the second half of the season (September to December 2020) the players ingested an additional supplement every evening pre-sleep, in addition to the one ingested after each training or home series match. Dataset containing PP and SQ measurements was divided and labeled as Smartfish period 1 and 2 prior to analyzes. Players who did not participate in the pre-sleep protein supplementation program were excluded from analysis.

Figure 11. Smartfish Recharge High Protein supplement. Information in the illustration refers to per 200 milliliters. kj: kilojoules, kcal: kilocalories, mg: milligram, g: gram. Source: Appendix 5.

2.4 Statistical analyzes

Primary outcome variable was the players peak HIR, investigated in relation to the exposure of minutes in DS. Furthermore, protein supplements as an exposure to players minutes in DS and peak HIR - and physical effort as an exposure to RR were investigated as secondary outcomes. Extreme outliers were investigated with boxplot inspections for values greater than three box-lengths from the edge of the box. No extreme outliers were detected. Examination of quantile-quantile (QQ) plots and Shapiro-Wilk tests for the primary outcome variable was performed, and data was considered normally distributed. Other data in relation to the analyzes was considered normally distributed, except RR. To adjust for repeated measurements, linear mixed model (LMM) was applied for both the association between DS and peak HIR, as well as secondary outcome associations. Results from LMM with subject as random factor, protein supplement dose, player position and setting as fixed categorical factors, and amount of DS the night prior to training or match as continuous covariate were applied in the model for the association between DS and peak HIR. Interaction test for the difference in dosage of protein supplement was applied for the association between DS and peak HIR in the LMM. For the association between effort and RR, results from LMM with subject as random factor, protein supplement dose, player position and setting as fixed categorical factors and amount of effort on training and match prior to RR the following night was applied as continuous covariate. Data was presented as mean ± standard deviation or standardized regression coefficient and 95% confidence interval. Where appropriate, data was presented in text, tables and figures. Significance level was set to $p<.05$. Since this was a pilot study, no sample size calculation was performed. Statistical analyzes was performed with the use of Statistical Package for the Social Sciences 26 (SPSS) (IBM Corp., Armonk, New York, USA). Graphical illustrations were made in SPSS and Microsoft Visio Professional® (Microsoft, Redmond, Washington, USA).

2.5 Research ethics

The present study was conducted according to the Declaration of Helsinki [(49)] and registered at the Norwegian Centre for Research Data (NSD). NSD required an assessment submission to be evaluated by Regional Committees for Medical Research Ethics (REC) since health and personal data was to be collected during the study (Appendix 6). REC concluded that the study did not need further approval, as it was not considered to be a health research project (Appendix 7). Thorough information prior to participation in the study was given to the participants, in order to make them fully understand what a consent implied. All participants could at any time withdraw their consent, without giving grounds or further reason. The study emphasized safe handling of data, using standard NTNU solutions for data processing and storage. In accordance with the subject's protection of privacy, the present study followed standards of the EU General Data Protection Regulation (GDPR).

2.6 Risk assessment of the project

As a prospective cohort study design, the monitoring did not increase any risks beyond regular soccer trainings and matches. The study was designed not to interfere with the players trainings and matches, nor their everyday life. The team already used ZXY before study start, and it was therefore of no inconvenience. Implementation and use of Somnofy was new for the team. The device is non-invasive, and no player expressed discomfort due to being monitored during sleep. The protein supplement used in the study has previously been clinically tested (Figure 11, Appendix 5).

3. Results

3.1 Subject characteristics

As presented in Figure 5, 7 players did not wish to attend the study and 2 goalkeepers were excluded in the recruitment period. Furthermore, 1 player got injured during the second half of soccer season and 2 players did not participate in the second half of the protein supplement period. As a result, the analyzes included 11 soccer players from the Norwegian elite soccer team Ranheim FC (mean ± SD age 23.8 ± 2.4 years, height 185.9 ± 5.1 cm, body mass 80.6 ± 6.1 kg). All 11 players provided training data (183 and 177 measurements for DS/peak HIR and effort/RR respectively) whereas 8 of 11 provided match data (62 and 59 measurements for DS/peak HIR and effort/RR respectively). Subject characteristics for all players are presented in Table 1 and divided by positions in Table 2.

Table 1. Subject characteristics, sum of all positions.

	All positions	
	Training (n=11)	Match (n=8)
PP	Mean ± SD	Mean ± SD
Total Distance (m)	6 417 ± 1 443	10 100 ± 2 158
Peak HIR (m)	67.3 ± 37.0	118.0 ± 43.5
Effort	9 652 ± 2 442	15 733 ± 3 185
Sleep	Mean ± SD	Mean ± SD
Total Sleep (hours)	7.7 ± 0.9	8.2 ± 0.9
DS (min)	83.5 ± 22.0	89.1 ± 18.1
RR	14.3 ± 1.6	15.2 ± 1.7

Note. Data presented as n= sample size, continuous variables presented as mean values ± SD. SD: standard deviation, PP: physical performance, m: meters, peak: highest consecutive 5-minute value, HIR: high intensity run, DS: deep sleep, min: minutes, RR: respiratory rate per minute.

Table 2**.** Subject characteristics divided by positions.

	Forwards		**Midfielders**		**Defenders**	
	Training (n=3)	Match (n=2)	Training (n=3)	Match (n=2)	Training (n=5)	Match (n=4)
PP	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Total Distance (m)	6173 ± 1424	8975 ± 1953	6690 ± 1493	10170 ± 2304	6390 ± 1410	10408 ± 2104
Peak HIR (m)	79.8 ± 40.7	173.1 ± 26.4	66.6 ± 32.3	105.7 ± 50.5	61.8 ± 36.5	106.4 ± 31.2
Effort	10355 ± 2714	15642 ± 2699	9263 ± 2158	14088 ± 2599	9505 ± 2396	16439 ± 3361
Sleep	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Total Sleep (hours)	7.4 ± 1.0	7.7 ± 1.4	8.0 ± 0.8	8.6 ± 0.5	7.7 ± 0.9	8.2 ± 0.8
DS (min)	90.7 ± 21.4	97.2 ± 16.8	77.9 ± 22.1	90.1 ± 15.1	83.0 ± 21.5	86.4 ± 19.1
RR	14.7 ± 1.0	15.8 ± 1.1	13.6 ± 1.6	14.5 ± 1.9	14.5 ± 1.6	15.3 ± 1.7

Note. Data presented as n= sample size, continuous variables presented as mean values ± SD. SD: standard deviation, PP: physical performance, m: meters, peak: highest consecutive 5-minute value, HIR: highintensity run, DS: deep sleep, min: minutes, RR: respiratory rate per minute.

3.2 Effect of deep sleep on peak high intensity run

DS was negatively associated with peak HIR, without significant results (95% CI [-.306, .084]) as shown in Table 3.

Table 3. Effect of deep sleep minutes on peak high intensity run meters.

Exposure variable DS (min)	b [95% CI]
Peak HIR (m)	-.110 [-.306, .084]

Note**.** b, regression coefficient for linear trend, adjusted for setting (training or match), player position (forward, midfielder or defender) and protein supplement (1 or 2 doses). Regression coefficient represents average increase in peak HIR meters per minute increase in deep sleep with 95% confidence interval (CI). DS: deep sleep, min: minutes, peak: highest consecutive 5-minute value, HIR: high intensity run, m: meters.

Scatter plot illustrates the effect of DS on peak HIR, adjusted for setting (training or match), player position (forward, midfielder or defender) and protein supplement (1 or 2 doses) – given in Table 3. Overall results indicate that increased DS is associated with reduced peak HIR among some players (Figure 11).

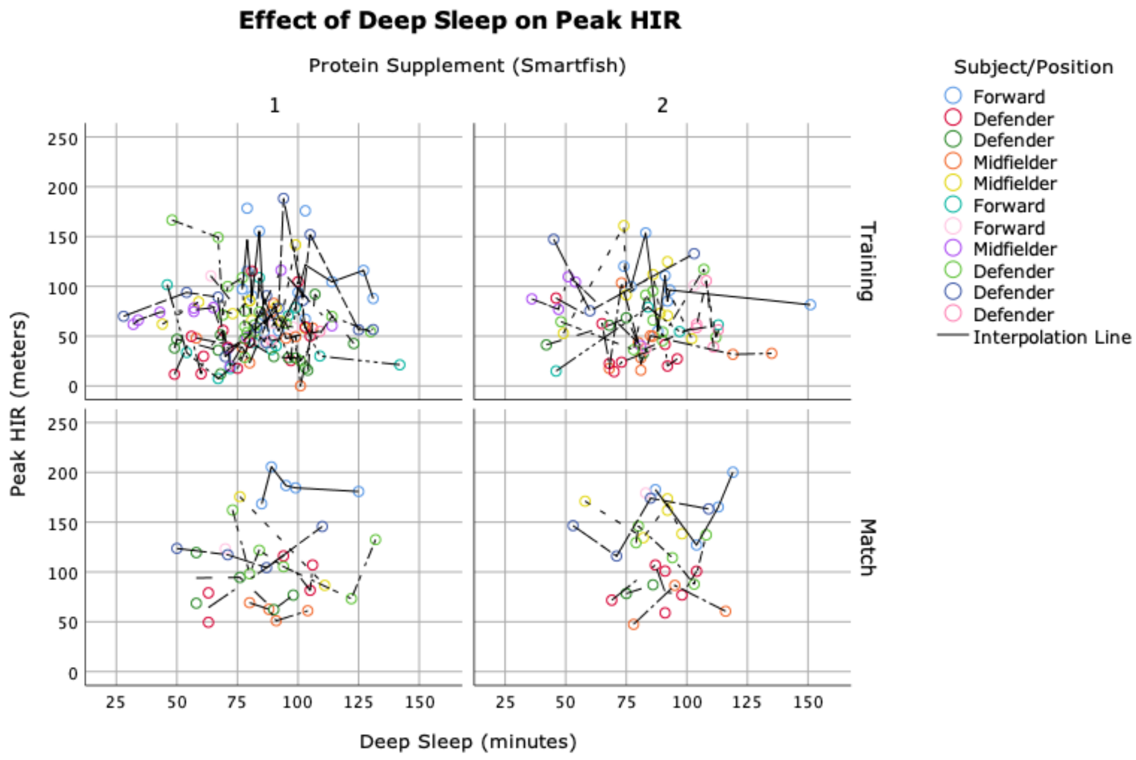

Figure 11. Scatter plot illustration the effect of deep sleep on peak (highest consecutive 5-minute value) high intensity run (HIR) with individual lines per subject, adjusted for setting (training or match), player position (forward, midfielder or defender) and protein supplement (1 or 2 doses).

3.3 Effect of pre-sleep protein supplement on association between deep sleep and peak high intensity run

The association between DS and peak HIR was not significantly different (p=.623) between 1 and 2 doses of protein supplement. The group specific estimates were close to equal between 1 and 2 doses (Table 4).

Table 4. Effect of deep sleep minutes on peak high intensity run meters with 1 and 2 doses of protein supplement.

	Protein Supplement (Smartfish)		
	1 dose	2 doses	
	b [95% CI]	b [95% CI]	p, interaction
Exposure variable DS (min)			
Peak HIR (m)	-.078 [-.313, .157]	-.172 [-.485, .141]	.623

Note. b, regression coefficient for linear trend, adjusted for setting (training or match) and player position (forward, midfielder or defender). Regression coefficient represents average increase in peak HIR meters per minute increase in deep sleep with 95% confidence interval (CI) – affected by protein supplement. DS: deep sleep, min: minutes, peak: highest consecutive 5-minute value, HIR: high intensity run, m: meters.

3.4 Effect of effort on respiratory rate

Effort showed close to none, but a minimal positive effect on RR during sleep, without significant results (95% CI [-.000007, .000046]) - shown in Table 5.

Table 5. Effect of effort on respiratory rate per minute.

Exposure variable Effort	b [95% CI]
RR	.00002 [-.000007, .000046]

Note. b, regression coefficient for linear trend, adjusted for setting (training or match), player position (forward, midfielder or defender) and protein supplement (1 or 2 doses). Regression coefficient represents average increase in respiratory rate per minute (RR) per one increase in effort with 95% confidence interval (CI).

4. Discussion

To the authors knowledge, no study has to date investigated SQ and its effect on soccer specific PP, using technology such as Somnofy, in a real-life scenario. In this pilot prospective cohort study on male elite soccer players, results show a slight negative, but not significant effect of DS on peak HIR. Furthermore, the association between DS and peak HIR is not significantly different between 1 and 2 doses of protein supplement. Lastly, effort show close to none, towards a marginally positive effect on RR, without significance.

4.1 Effect of deep sleep on peak high intensity run

Several studies have acknowledged the effect of sleep on PP outcomes with conflicting results – in different settings, sports and with different methodology. Based on previous research, the hypothesis was that DS would have an effect on peak HIR among male elite soccer players. Although not significant, results show a slight negative association between DS and peak HIR. By increasing DS with one minute, peak HIR was reduced with .110 meters on average.

The present finding is in contrast to a majority of previous research regarding sleep loss of varying lengths. In anything from 4-5 hours of sleep to 64 hours of total sleep deprivation, it's been reported of reduced PP for speed and endurance variables during submaximal exercise among athletes, measured in standardized tests (16,18,24,30). However, some studies state that short-term high-power tasks, maximal efforts and single bouts of aerobic exercise among athletes were mostly unaffected from similar length sleep deprivation (16,19). These findings are somewhat in agreement with present results, as the negative impact of DS on peak HIR is low. This may indicate that peak HIR could be largely unaffected even with a change in duration of sleep. It is however speculated that a decrease in PP of any kind as a result of insufficient sleep could be mediated by motivation (30). Elite athletes with insufficient sleep have previously shown decreased PP, likely a consequence of sleep loss, possibly mediated by motivation (20). On the other hand, Roberts et al. (2019) investigated the effect of prolonged time asleep on PP. In contrary to the present study, they found an increase in PP as a result of longer total sleep time among athletes (34). However, a recent study using Somnofy to monitor endurance athletes in real-life scenarios, discovered that increased sleep durations, including increased DS, led to reduced PP (20). This is in agreement with the present study and strengthens results. It may further indicate that real-life scenarios provide different results regarding sleep and its effect on PP compared to standardized tests, which further might require a need to tailor interventions to real-life scenarios. Regardless, overall comparisons must be interpreted cautiously due to difference in methodology, setting and equipment.

It could however be possible that players in the present study had sufficient sleep, thereby potentially making the effect of DS on peak HIR random. Players achieved approximately eight hours of sleep per night on average, which is within general sleep recommendations (17). This is unlike statements from previous studies which report of athletes usually sleeping less (16,18,20). Still, it is uncertain whether general recommendations regarding sleep is sufficient for athletes. To date, it has not been established what amount of total sleep or SQ athletes need, though some suggest athletes may need as much as 9-10 hours of sleep per night (18,19). Players in the present study achieved general sleep recommendations for non-athletes, but still experienced a reduction in PP. This may indicate a need for increased sleep among athletes compared to non-athletes, as previously suggested [18,19]. Furthermore, the sample in the present study were professional soccer players, who all either worked or studied in addition to playing soccer. This could mean that the stressors of life that influence sleep might impact this population more so than other fully professional teams, further increasing the players need for sleep. This should be considered regarding interpretation of the present results.

Contrary to the impression that more sleep leads to increased PP, one could speculate that an increase in fatigue could lead to an increase in DS – thereby making increased DS an indicator of fatigue or need of recovery, instead of capability of PP. Players would then hypothetically have a reduced PP in cases of more DS, which is the tendency of present results. This has been suggested by recent research, where results showed a reduced PP following increased DS, possibly due to elevated need of recovery [20]. A hectic match schedule became the result of the ongoing Covid-19 pandemic. As a result, the increased load put on the players might have led to increased fatigue and need for more sleep, but not necessarily performance gains as a result of the increased DS [5]. Differences in peak HIR in soccer could vary from several game related factors besides DS as well. A study discovered that HIR meters were significantly lower for the winning opposed to the losing team, likely due to the latter struggling for possession, while the leading team had control of the ball [37]. Another possibility is that players might tend to play the game of soccer better if sleep the prior night was sufficient. Improved SQ may lead to improved cognitive function and thereby better decision making, resulting in decreased PP. Kunrath et al. (2020) discovered that total distance during match play could increase as a consequence of reduced cognitive function and ability to make good tactical decisions, while high-effort movements similar to peak HIR was reduced [2,50].

Trainings and matches varied both in days and time of day. Thun et al. (2015) stated that time of day might affect PP, where results showed that maximal PP is likely to be achieved sometime around the early evening for single PP tasks, as the circadian rhythm peaks body temperature, but earlier in the afternoon for technical exercises like soccer [30,32]. This was not accounted for in the present study. The timing of trainings and matches might have impacted sleep in several ways. Having trainings and matches earlier in the day gives players time to rest afterwards. In turn, having especially matches late in the day, could lead to difficulties in sleep onset for players, as high intensity exercise, high level of concentration and possible caffeine intake prior to sleep is not recommended [18,20,30]. Additionally, players typically have to wake up early the next day for a recovery session, further implicating their sleep, which for the present population also includes work or attending classes [20,33].

Furthermore, one could argue that training sessions in the present study were not adequate representations of match play, meaning that measurements of peak HIR might be underestimated as a result of the training exercises, not necessarily the effect of varying DS. The different activities during selected trainings might not have been appropriate for measurements of 5-minutes, as has been reported for small-sided games exercises previously [46]. It is possible that peak 3-minute periods would have provided different results, as soccer training exercises are typically intermittent and for shorter periods of time [1]. However, 3-minute periods might again be too short, not representative of the most intense period of match play [12,13]. Still, peak HIR was chosen as the measure of PP over other used variables e.g., sprint, acceleration and total distance. Previous research pointed towards HIR being the most common measurement, while other variables vary greatly between positions [8,11]. However, future studies could apply position specific variables for even more precise measures.

Findings from the present study indicated that DS did not seem to be a decisive factor in relation to PP of soccer players, in an everyday life scenario. However, results should be interpreted carefully. The study was conducted as a pilot study, and level of significance as well as the results themselves may be affected by the low sample size. Additionally, players slept better on average than previously reported athletes, which raises the suspicion that the present study is represented with participation bias. It is possible that those who slept insufficient might have been hesitant to participate. Regardless, results may have been different if players slept poorer, and future studies are therefore recommended to retain the exposure and outcome variables, but also increase the sample size, as well as include all players.

4.2 Association between deep sleep and peak high intensity run affected by pre-sleep protein supplement

Results from the present study show no significant difference between ingesting one dose of protein supplement after each training and match, and ingesting an additional dose pre-sleep, on the association between DS and PP. The group specific estimates were close to equal between the two dosages. The hypothesis was that pre-sleep protein supplement would have an effect on the association between DS and peak HIR. It could be speculated if one dose might have been sufficient, since it was ingested at the optimal time (post exercise), thereby achieving all benefits from protein supplementation prior to the pre-sleep supplement, making it superficial. Trainings did not achieve the same PP intensities as match play (Table 1), and only 8 out of 11 players in the study sample provided match data. This could indicate that the total load players endured did not require the additional pre-sleep protein supplement, especially for those who did not play matches. Previous studies have assessed dosages of 20-40g of protein per day with positive results [39,41]. 1 Smartfish protein supplement only contains 15g of protein, which should make 2 suitable according to previous research. However, assessed dosages were in relation to resistance training, and might not be applicable for soccer related PP, as it did not appear to have similar impact in the present study. Additionally, dosages were not tailored according to bodyweight recommendations [35,41], which may have affected present results. Furthermore, it is possible that pre-sleep protein supplementation might have had a bigger impact if the effect of DS on peak HIR was greater for the main outcome. Since players seemed to sleep superior to previously reported athletes, the effect of pre-sleep protein supplement might be underestimated. It could be hypothesized that if time in DS was reduced, protein supplements could aid the possible recovery shortage created, and PP might still have been maintained [5,27,35,39]. As the sample in the study were professional soccer players, it is possible that eating healthy in general was a priority and may have got necessary nutrients from diet alone [27,35].

As mentioned, a hectic match schedule became the result of the ongoing Covid-19 pandemic. The team played an average of about 1.5 matches per week, with the most frequent being 3 matches in 7 days. Dupont et al. (2010) found that an increase in frequency of matches from 1 to 2 per week increased the risk of fatigue related injuries by over 6 times [33,37]. Players were therefore consequently exposed to an elevated risk of injury. Still, only one long term injury occurred, despite the risk being sixfold [37]. It could be suspected that the protein supplement aided recovery, avoiding injuries that would otherwise occur, even though there were no significant difference between dosages. It is possible that pre-sleep protein ingestion, that was performed during the second half of the season, improved SQ that would otherwise be reduced as a result of fatigue that progressively increases during soccer season [47]. A limitation within the study design is controlling for confounding factors (e.g., diet and recovery exercises) which makes it difficult to assess the effect of pre-sleep protein supplement. An alternative could be to provide some players pre-sleep protein supplements from the beginning of the season, not just in the second half, and some not at all.

4.3 Effect of effort on respiratory rate

Since RR is a strong predictor of physical effort while awake, it was hypothesized that effort might have an effect on RR the following night [23,44]. Results from the present study were without significans, and showed close to none, towards a minimally positive effect of effort on RR the following night. The effort players endured on trainings was lower compared to match play on average, and might have been too low to impact RR. If RR was to be affected by effort, it is fair to assume that the effort would have to be quite substantial to affect the body's physical recovery processes during sleep [23]. As mentioned, timing of trainings and matches varied. There is a possibility that timing might have impacted RR as well. If the physical load a player endured was performed earlier in the day, he would then have more time to recover as the day progressed, and the impact on RR the following night might decrease and be underestimated. It may further be underestimated due to protein supplement ingestion that may have aided the recovery process [28,35,41,42]. Despite a low of effort on RR in the present study, it could be an interesting topic for future studies investigating sports requiring of greater physical loads, where results might be more applicable.

4.4 Conclusion

The study was conducted with a small sample size and there was a lack of significance. However, results showed a tendency towards peak HIR being negatively affected by increased DS. Still, overall findings indicate that DS did not seem to be a decisive factor in relation to PP of soccer players, in an everyday life scenario. Targeting sport specific PP outcomes in real-life scenarios may be of importance. In final, a need for larger studies to confirm the presented results are warranted.

4.5 Limitations of the study

The present study was conducted as a pilot prospective cohort study, and the sample size was low. The representativeness of the study population is uncertain, as participation was voluntary, and the attending players slept superior to previously reported athletes. Furthermore, the study represents some additional inherent limitations. Placement of the ZXY transponder, which was not optimal for measurements of effort according to recommendations (Appendix 1). A low sample size made it difficult to divide data in different categories, e.g., low, medium, and high PP and additionally made positional separation of players sub-optimal. Progressive seasonal fatigue, timing of exercise, player's diet and possible recovery exercises were not controlled for. Optimally, only match data would have been assessed. Trainings were included as supplementary measurements due to low amount of match data. Although substantial agreement in measurements between Somnofy and polysomnography, it was not flawless, and precision of the device when there are two subjects in the bed is not certain [(26)]. Players partners could have taken their place after they woke up and sleep sessions would still continue, which also applies for merged sessions. An attempt to control for this was made by cross-examining the time of training sessions with the time players woke up. Players might have followed general sleep advice to a greater extent than normal due to being monitored and powernaps during daytime was not controlled for. Lastly, to perform a LMM, the outcome variable is required to be normally distributed, which RR was not. The LMM was still applied for the association, in lack of a more suitable test. Results from the present study is mainly applicable for elite soccer players. However, it could be debated that due to the present study sample having regular jobs and attending school in addition to playing soccer, results may be relevant for adult soccer players in general.

5. Funding

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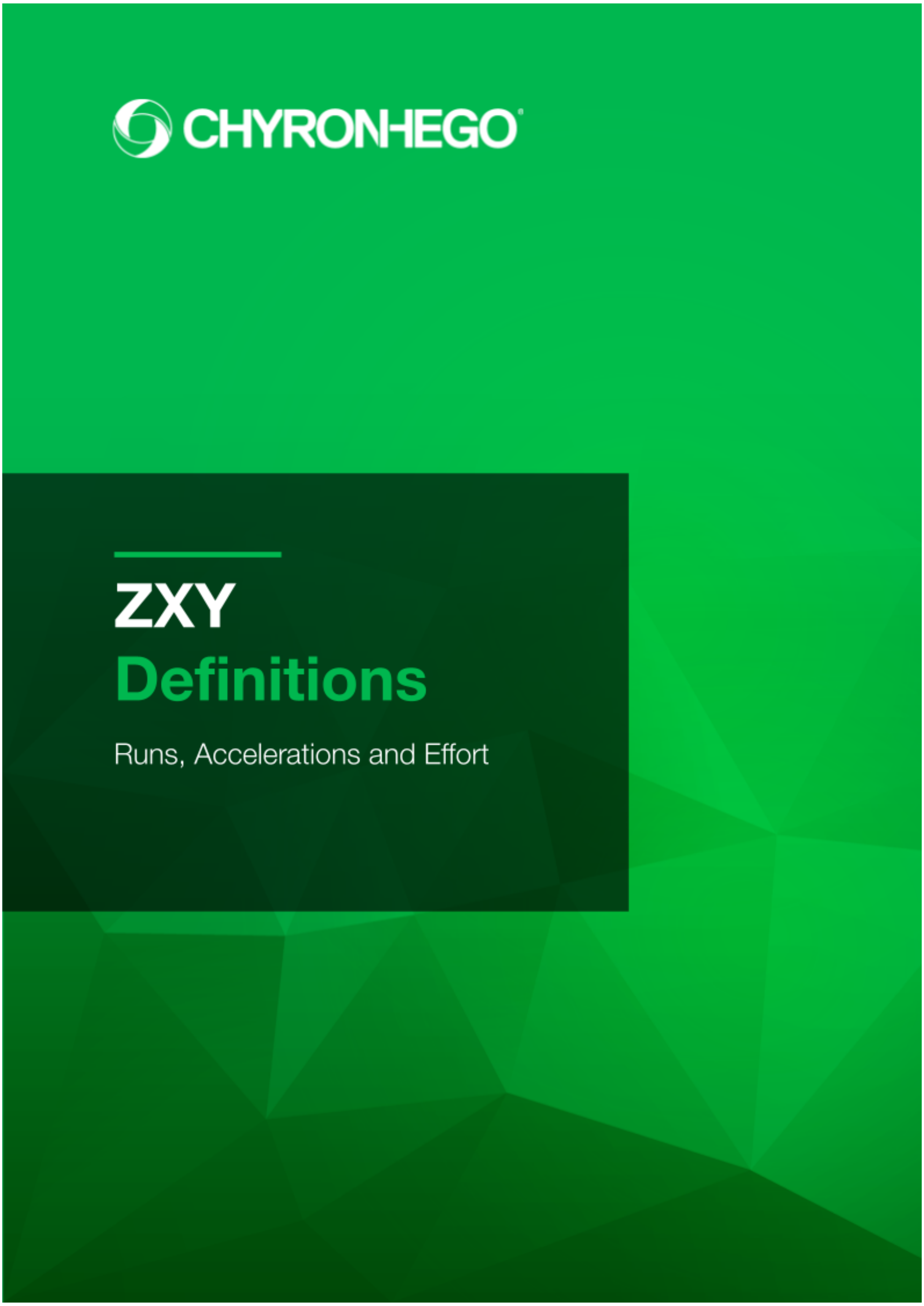
Appendix 1: ZXY Sport Tracking definitions (eight pages)


CHYRONHEGO

ZXY

Definitions

Runs, Accelerations and Effort

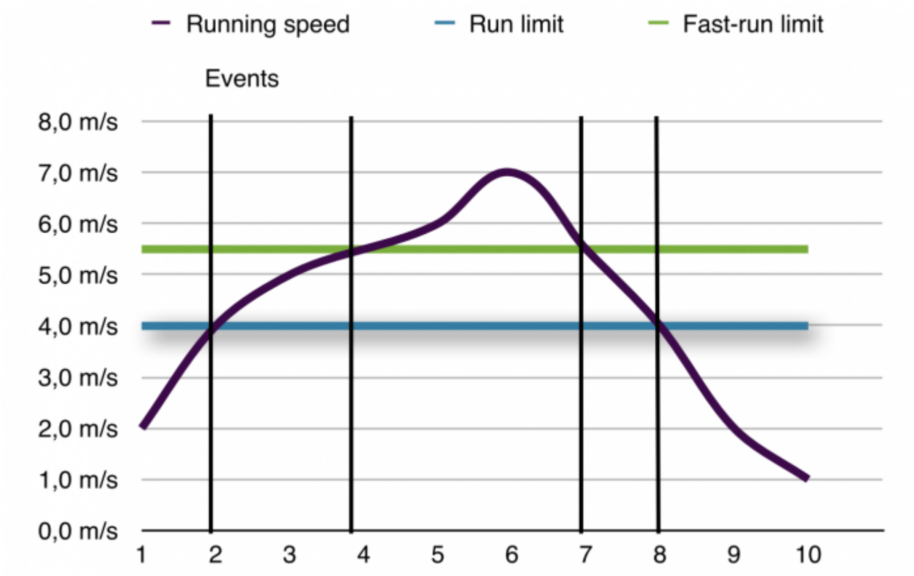
TABLE OF CONTENTS

RUNS

Definition

A run is defined by 4 event markers:

1. The speed increases above the run speed limit. This marks the start of the run event. Distances and effort is calculated from this point. At this point the speed must be above the minimum speed which is defined to be 4m/s.
2. The speed increases above the fast-run speed limit. This is required for a run to be counted as a run. Also the player should be in this zone at least 1 second.
3. The speed decreases below the fast-run speed limit.
4. The speed decreases below the run speed level. This marks the end of a run.



Data

The following data is stored in the database for each run:

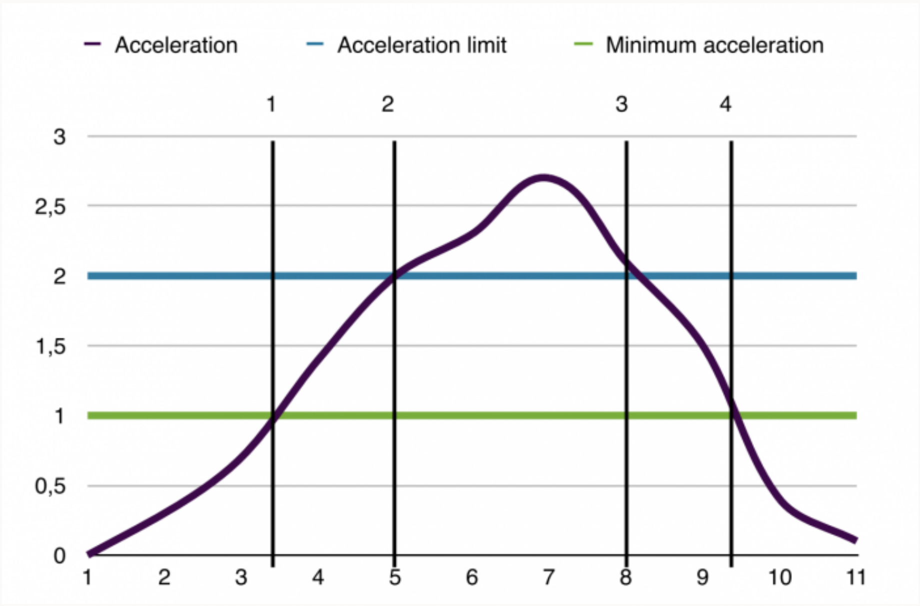
- The timestamps for the four event markers.
- The maximum speed, and the timestamp for the maximum speed.
- Total effort
- Effort between the event markers
- Total distance.
- End position.
- Start position.

ACCELERATIONS

Definition

An acceleration is defined by 4 event markers.

1. The acceleration reaches the minimum acceleration. This marks the start of the acceleration event.
2. The acceleration reaches the acceleration limit. The acceleration must be over this limit to be counted as an acceleration event.
3. The acceleration must remain above the acceleration limit for at least half a second.
4. The acceleration goes below the minimum acceleration. This marks the end of an acceleration event.



Data

The following data is stored in the database for each acceleration:

- The timestamps the start and end for an acceleration (Event 1 and 4).
- Total effort
- Total distance.
- End speed.
- Start speed.
- Mean acceleration.

EFFORT

Definition

The effort represents the absolute movement of a player in any direction.

For good effort measurements the transponder should be firmly attached to the center of mass of the athlete (i.e. a belt worn tightly around the waist).

The effort is derived from the accelerometer 3-dimensional vector information and is calculated in the following way:

1. Subtract gravity (x y z)
2. Normalize(x^2+y^2+z^2)

ABOUT CHYRONHEGO

ChyronHego, a portfolio company of Vector Capital, is a global leader in products, services, and solutions for the broadcast and sports industries. Specializing in live television, news, and sports production, ChyronHego offers some of the industry's most widely deployed solutions — including Lyric®, the world's most popular broadcast graphics creation and playout offering; the all-new CAMIO® Universe newsroom workflow; and TRACAB® Optical Tracking, the global leader in optical sports tracking systems as well as Click Effects, the most proven and versatile stadium broadcast family of graphics products. Headquartered in Melville, New York, ChyronHego also has offices in the Czech Republic, Denmark, Finland, Germany, Mexico, the Netherlands, Norway, Singapore, Slovak Republic, Sweden, and the United Kingdom.

For more information on ChyronHego, visit www.chyronhego.com.

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JOIN THE CONVERSATION ONLINE WITH CHYRONHEGO @

www.chyronhego.com

Appendix 2: ZXY Sport Tracking transponder information

CHYRONHEGO

GEO TRANSPONDER
PRODUCT INFO

GEO Transponder

High-precision GNSS transponder for real-time positioning

The most accurate GNSS transponder for football on the market (ref. FIFA ETPS Validation Study). Used for outdoor and small stadiums with TRACAB GO. Compatible with third party sensors via Bluetooth, such as heart rate monitors.

Specifications

Sizes and Weight	
Dimensions (WxLxD)	90 x 45 x 15 mm
Weight	63 g

Radio	
Frequency (Configurable)	5 - 5.9 GHz
Power Emission	0 - 10 dBm

Battery	
Type	Lithium Ion
Duration	8 hours

Interfaces	
Bluetooth	4.0 (Low Energy)

Sensors	
GNSS	10 Hz GPS, GLONASS, GALILEO
IMU	Accelerometer, Magnetometer and Gyro
Temperature	-20 to 60 °C

FOR MORE INFORMATION ABOUT CHYRONHEGO VISIT:
HTTP://CHYRONHEGO.COM/

Appendix 3: ZXY Sport Tracking FIFA validation study results

CHYRONHEGO

GEO TRANSPONDER
PRODUCT INFO

FIFA EPTS Validation Study Results

VICTORIA UNIVERSITY MELBOURNE AUSTRALIA

CHRYON HEGO GPS

FIFA

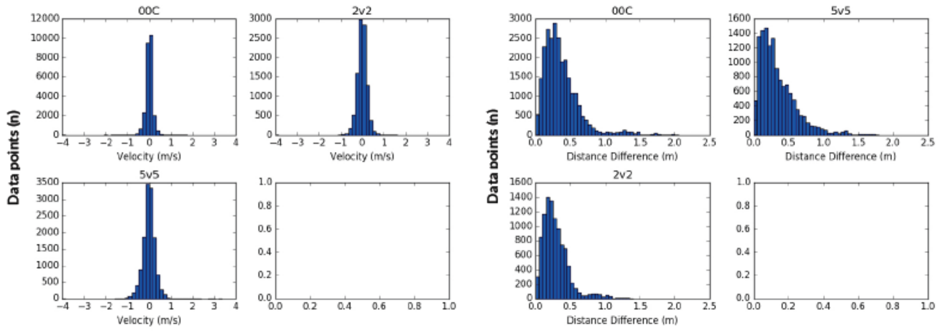
Rating by FIFA Velocity Band

	0-7 km/h	7-15 km/h	15-20 km/h	20-25 km/h	25+ km/h
Velocity RMSD (m/s)					
Position RMSD (m)					
Velocity mean difference (m/s)	0.06	0.04	-0.10	-0.11	
Velocity SD difference (m/s)	0.15	0.19	0.13	0.06	

Legend	Well-above	Above	Standard	Below	Well-below

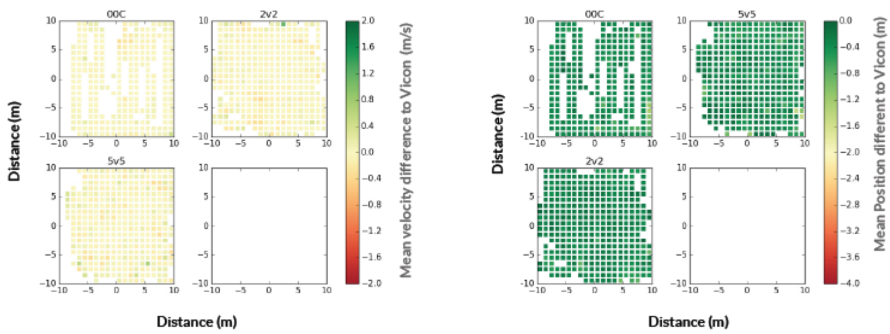
Histogram of Velocity Differences (m/s)

Histogram of Position Differences (m)



Mean velocity difference to Vicon (m/s)

Mean position difference to Vicon (m)



FOR MORE INFORMATION ABOUT CHYRONHEGO VISIT:
HTTP://CHYRONHEGO.COM/

Appendix 4: Somnofy setup instructions

1. Download the Somnofy app (Appstore → Somnofy Research).
2. Connect the Somnofy device in your bedroom using the cable supplied in the box.
3. Open the app and allow Bluetooth to be connected.
4. Scroll right through the information on the screen.
5. Press "existing user ".
6. Where it says E-mail; enter the first two letters from your first and second name, followed by the last two digits of your birth year, and add @hotmail.com. For example: crro85@hotmail.com if you were Cristiano Ronaldo.
7. The password is X with a capital X. Change password in the app after initial log in.
8. Press the lines to the top left → under settings press "device", scroll down and press "configure wifi".
9. Choose your wifi and enter the password.

If you share the bed with a partner you have to measure the distance from the Somnofy to the middle of the bed and enter that distance in the app under "device distance".
Enter your height and weight for more accurate measures.
Put the device on a nightstand or a chair near your bed, on the same height or higher than the bed, pointing towards your chest.
After everything is done, please leave the bedroom and allow the device to get acclimated.

Appendix 5: Smartfish datasheet

RECHARGE HIGH PROTEIN

For improved muscle recovery

NUTRITIONAL VALUE PER SERVING 200 ML

ENERGY	842 kj (202 kcal)
FAT	8,4 g
- SATURATED	2,2 g
- OMEGA 3	1400 mg
- EPA	440 mg
- DHA	660 mg
CARBOHYDRATES	14,6 g
- SUGARS	14 g
- LACTOSE	0,08 g
FIBRE	3,4 g
PROTEIN	15 g
SALT	0,2 g
LEUCIN	2,2 g
VITAMIN D	3 µg

RECHARGE HIGH PROTEIN
Berry and fruit juices, whey proteins, leucin (amino acid), vitamin D, EPA and DHA in a tasty, smoothie-like blend. The marine oil in Smartfish is oxidation-protected, not concentrated and of Norwegian origin. RECHARGE HIGH PROTEIN is a foodstuff for particular nutritional use and a recovery drink used in connection with physical training. People performing intense physical exercise burn more DHA and EPA.

The drink is juicebased with juices of aronia, pommegranate, apple and pear. No added sugars, sweeteners or preservatives.

USAGE AREAS For improved recovery after exercise.

IMPORTANT NOTES Should not be consumed by persons with milk protein allergy. Contains whey protein from milk.

PACKAGING Cartons of 200 ml (8 oz).

USE Serve chilled, shake before use. The drink will obtain a thicker texture/mouthfeel if it is served at low temperature.

STORAGE Store in ambient/room temperature 1-25°C, out of direct sunlight. Open containers may be stored in a refrigerator for up to 24 hours.

PRODUCTION AND GMO The fish oil source are wild catch from Norwegian waters, fully traceable and certified GMP. Smartfish does not contain GMO and is not produced from GMO.

SMARTFISH AS Smartfish leads the development of nutritional drinks with oxidation-protected marine omega 3 fatty acids. The company has an extensive clinical trial program.

SPORT

SMARTFISH SPORTS NUTRITION

Oslo Innovation Centre
Gaustadalleen 21
0349 Oslo
Norway
smartfishsport.no/en

Appendix 6: Research protocol

§8 - Forskningsprotokoll

a) *Prosjektleder*

Ulrik Wisløff og Arnt Erik Tjønna

b) *Prosjektplan*

Med et tett kampprogram i OBOS ligaen er fokuset på restitusjon større enn noen gang, både for å være restituert til nye kamper og treninger, så vel som å holde seg skadefri. I dette prosjektet er det totalt 5 studenter med varierende oppgaver. Det er viktig å presisere at ingen av masteroppgavene er til hinder for eksisterende praksis hos lagets fysiske og medisinske team.

1. Studere effekten av isbadprotokoll på:

1. Opplevd fatigue
2. Objektive mål på fatigue, CRP og hopphøyde dagen etter kamp
3. Fysisk prestasjon på trening og kamp målt med ZXY Sport Tracking
4. Søvnkvantitet og kvalitet målt med Somnofy
5. Skadefrekvens

Spillerne får daglig SmartFish proteintilskudd rett etter trening eller kamp, noe de allerede har startet med, og isbad innføres etter alle hjemmekamper. Vi vil ikke ha tilgang på isbad rett etter bortekamper og disse kampene vil da være «kontroller» i denne studien.

2. Studere effekten av å innta proteintilskudd før man legger seg (i tillegg til tilskuddet etter trening/kamp samt isbad protokoll) på:

a. Søvnkvalitet

b. Alle parameterne som beskrevet i oppgave 1 ift. fatigue, men utelater ZXY analysen

3. Studere effekten av ekstra proteintilskudd (før leggetid) på fysisk prestasjon på treninger/kamper målt med ZXY.

4. Ren ZXY-analyse for å studere fotballaget i kamp og på trening (rollespesifikt) med daglig rapportering. Målet med studien vil være å undersøke om vi klarer å gjenskape fysisk intense perioder i kamp i de «standardiserte» treningsøvelsene vi gjør hver uke (7v7, 3v3 osv.). Utfallsmål vil være antall akselerasjoner/retardasjoner, antall sprinter i de mest intense 5-minuttersbolker i kamper mm.

5. Koble video/fysisk analyse til ZXY data for å analysere hvilke aksjoner som foregår i hendelsesforløpet før målscoringer.

ZXY Sport Tracking er en del av spillernes normale hverdag. Det er en liten brikke som spillerne har på ryggen under hver trening og kamp. Ved bruk av disse og systemet som er innebygd på stadion vil vi kontinuerlig måle objektive data på hvilke fysiske aksjoner spillerne utøver på banen. Videre vil det sendes en summert ukes belastning per spiller til

Appendix 7: Assessment submission and response from REC (two pages)

REK
REGIONALE KOMITEER FOR MEDISINSK OG HELSEFAGLIG FORSKNINGSETIKK

Region:	**Saksbehandler:**	**Telefon:**	**Vår dato:**	**Vår referanse:**
REK midt	Karoline Bjørstad Berget	73597509	11.01.2021	217444
			Deres referanse:	

Arnt Erik Tjønna

217444 Restitusjonstiltak og analyse av mannlige norske fotballspillere

Forskningsansvarlig: Norges teknisk-naturvitenskapelige universitet

Søker: Arnt Erik Tjønna
Søkers beskrivelse av formål:
Prosjektet har flere formål.

ZXY Sport Tracking (objektiv måling av fotballspillere) – Målet er å undersøke de fysiske kravene i kamp og sammenligne dette med trening. I tillegg får vi et innblikk i fysisk belastning i hver treningsuke og kravene til ulike øvelser brukt på trening. ZXY Sport Tracking er en del av spillernes normale hverdag. Det er en liten brikke som spillerene har på ryggen under hver trening og kamp. Ved bruk av disse og systemet som er innebygd på stadion vil vi kontinuerlig måle objektive data på hvilke fysiske aksjoner spillerne utøver på banen. Videre vil det sendes en summert ukesbelastning per spiller til trenere og den spilleren det gjelder. Dette vil bli gjort av laget uavhengig av dette forskningsprosjektet. Ingen personopplysninger utover navn registreres med ZXY Sport Tracking.

Kamera/videoanalyse – Målet er å undersøke hvilke fysiske aksjoner som skjer i spilloppbyggingen til et mål eller målsjanse. Video opptak fra kampene som har blitt sendt på TV vil bli brukt.

Somnofy/søvn (Somnofy er en kontaktløs søvnmåler) – Somnofy-data analyseres opp mot ZXY-data for å se hvordan søvn påvirker fysisk prestasjon på banen. Videre vil vi se på hvordan tilførsel av protein (SmartFish) påvirker restitusjonsprosessen og ulike søvnvariabler. Somnofy vil brukes av utvalgte spillere hver natt. Dette er en trådløs monitor som settes opp en gang og måler kontinuerlig etter dette. Somnofyen måler objektivt ved hjelp av innebygd radar variabler som total søvntid, tid før personen sovner, tid personen sovner, tid personen våknet opp, respirasjonsrate, tid i forskjellige søvnsoner, total tid i sengen, romtemperatur, luftfuktighet, luftkvalitet, lys, lufttrykk og lyd. Den har ikke mulighet til å ta opp lyd eller bilde/video. Data vil hele tiden være tilgjengelig for spillerne selv, men vi som har om søvn i dette prosjektet vil også få tilgangen til dataen. Ukesrapporter vil også her bli summert og sendt til trenere og den spilleren det gjelder. Også verdt å bemerke her at dette er noe som Ranheim hadde planlagt å implementere uavhengig av dette prosjektet.
Personopplysninger som registreres ved Somnofy er navn, høyde, fødselsår og kjønn.

Restitusjon - Isbad vil implementeres da det er effektivt for å forkorte restitusjonstiden etter hard fysisk belastning. Vil bli målt ved rating of fatigue (subjektivt mål på spillernes tretthet), hopptest som viser spillernes evne til å utføre eksplosive aksjoner som kreves i kamp og trening (objektivt mål for tretthet/restitusjon) og blodprøver til å måle inflammasjon (bilde på kroppens restitusjon).

REKs vurdering

Vi viser til innsendt fremleggingsvurderingsskjema datert 08.12.2020. Henvendelsen ble behandlet av komiteens leder.

Vurdering

Vurderingen er gjort med bakgrunn i de innsendte dokumenter. Vi oppfatter prosjektet som annen type forskning enn helseforskning. Prosjektet kan følgelig gjennomføres og publiseres uten godkjenning fra REK.

Merknad

Vi minner om at vurderingen er gjort med bakgrunn i de innsendte dokumenter og kun er å betrakte som veiledende, jf. forvaltningsloven § 11. Dersom du ønsker at det skal fattes et formelt enkeltvedtak etter forvaltningsloven, må du sende inn en full prosjektsøknad til REK. En prosjektsøknad blir komitébehandlet iht. oppsatte frister. Dersom det gjøres endringer i prosjektet, kan dette ha betydning for REKs vurdering. Det må da sendes inn ny søknad/framleggingsvurdering.

Vedtak

Ikke fremleggspliktig

Med vennlig hilsen

Vibeke Videm
Professor dr. med. / Overlege
Leder, REK Midt

Magnus Alm
rådgiver, REK midt

Norwegian University of
Science and Technology