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Poor sleep is related to lower general health, increased stress and increased confusion in elite Gaelic athletes
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Introduction:

Sleep is an essential component of human function and survival. Persistent poor sleep has a cumulative long-term negative effect on the human immune system, resulting in increased susceptibility to infections [1], and is associated with a range of adverse health outcomes [2, 3]. Sleep deprivation studies report a significant association between poor sleep and decreased cognitive function [4], decreased mood [5], and decreased physical performance [6]. All of these parameters are important components in an athletes' ability to train consistently and improve athletic performance. Consequently, sleep is considered one of the primary methods of recovery in athletes [7].

Monitoring athlete wellbeing is considered essential to guide training, and detect those at risk of overtraining syndrome (OTS), non-functional overreaching (NFOR), potential injury and illness [8]. Both OTS and NFOR are characterised by a combination of excessive overload with inadequate recovery, resulting in long and short-term decrements in performance [8] which interferes greatly with athletes' optimal preparation for competition & high performance [9]. Sleep quality has been cited as an integral component of recovery and management of the multi-factorial presentation of OTS and NFOR [10]. Inadequate or poor sleep is likely to become problematic in athletes at risk of and recovering from OTS and NFOR [11]. Athlete wellbeing monitoring, combining objective (i.e. blood markers, oxygen consumption) and subjective (i.e. mood, stress, sleep quality) measures can be used to monitor the athletes' response to training [12]. While a recent systematic review reported that subjective measures may be more representative of athletes' response to training load, compared to more expensive objective measures [13], it is unclear how these subjective measures of sleep, mood and stress interact with each other.

The amount of sleep, the quality of sleep, as well as the timing of sleep, have been identified as key factors in an athlete's ability to train, maximise their training response, recover and perform. [14]. A recent study of 124 elite athletes from individual and team sports, reported that athletes recorded a mean of 6.8 hours (hrs) sleep per night [15]. This is below the estimated "basal sleep need" for adults of seven to eight hrs [4]. Additionally, 50% of 175 elite rugby and cricket players were reported to be "poor sleepers" using the Pittsburgh Sleep Quality Index (PSQI) [16]. Although sleep is considered the primary method of recovery in athletes, it appears that a significant proportion of athletes have sub-optimal

sleep profiles, though there remains no clear consensus on what constitutes adequate sleep for athletes

The Gaelic Athletic Association (GAA) is an amateur sporting organisation in Ireland, which represents the most popular sports in the country; Gaelic football and hurling. Although predominantly concentrated in Ireland, there are GAA associated competitions worldwide including Britain, Europe, United States, Middle East, Asia and Australia. Match-play is characterised by intermittent bouts of multidirectional running and sprinting with elite players covering approximately 9k per game [17].

As discussed, there is evidence that athletes in a variety of sports have sub-optimal sleep profiles [16], despite this, there is no study to date on the sleep profile of GAA athletes. Short sleep duration (6.7±1.2hrs) was reported in Australian Rules football (AFL) players [15]. A 6-week sleep optimisation study, in a separate group of AFL players resulted in improved total sleep time and efficiency and corresponding increased wellbeing of vigour and decreased fatigue [18]. It is currently unknown if elite GAA athletes have poor sleep profiles and if they would potentially benefit from sleep interventions.

This study examines the sleep profile of GAA athletes, and compares how poor sleep relates to common subjective wellbeing measures, including subjective health complaints, painful body parts, mood, stress and catastrophising. The aims of this study were to measure the sleep profiles of elite GAA athletes and to examine if there was a relationship between poor sleep and subjective wellbeing measures.

Methodology

Participants

Following approval from the local University Ethics Committee, 69 from a possible 106, elite male GAA athletes volunteered to participate in the study. Participants were members of three regional elite GAA teams (mean ±SD = 22.7±4.1 years): one senior-level Gaelic football, n=28 (23.5±4.3 years), one senior-level hurling, n=22 (24.6±3.9 years), and one under-21 Gaelic football, n=19 (19.3±0.8 years). All participants provided written informed consent. Participants were excluded if they were not part of the elite regional team or were unavailable on the day of testing. Results were coded and available to researchers only.

Research design

This study forms part of a prospective observational study. Sleep quality, subjective health complaints, number of painful body parts, mood, stress and catastrophising were assessed in a questionnaire format using validated outcome measure which are detailed below. The questionnaires were administered by the team physiotherapist as part of the teams' pre-season testing, before they began pre-season training. The questionnaires took approximately 15 minutes to complete.

Procedures

Pittsburgh Sleep Quality Index (PSQI)

Sleep was measured using the PSQI, a standardised self-report sleep questionnaire. PSQI is a 19-item self-rated questionnaire for evaluating subjective sleep quality over the previous month [19]. The PSQI has seven sub-scale measures; subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction. The sum of these sub-scale scores provides a global score (0-21) which is a composite of sleep quality and quantity, with higher scores indicating worse sleep quality. Acceptable measures of internal homogeneity, reliability and validity have been obtained for the PSQI [19]. The PSQI has a sensitivity of 89.6% and specificity of 86.5% for identifying sleep disorders, using a cut-off score of five [19]. The correlation between PSQI and sleep log data has been found to be high and significant (r=0.81 for sleep duration and r=0.71 for sleep onset latency) [20].

Subjective Health Complaints Inventory (SHC)

Subjective health complaints were measured using the validated SHC [21]. The SHC questionnaire includes the most frequent health concerns and reasons for an encounter with a general practitioner and thus can be considered an indicator of overall general health [22]. Respondents were asked to report if they had experienced any of the following complaints during the last 30 days: palpitations/extra heartbeats, chest pain, breathing difficulties, heart burn, stomach discomfort, diarrhoea, constipation, eczema, tiredness, dizziness, anxiety and depression. Items such as sleeping problems and musculoskeletal pain were removed as they were covered elsewhere in the questionnaire. Severity of each complaint is rated on a four-point scale (0=none, 1=some, 2=much, 3=severe) [21]. Internal consistency of SHC yielded a Cronbach's alpha of 0.82 for women and 0.75 for men [22].

Nordic Musculoskeletal Questionnaire (NMQ)

The NMQ was used to identify the number of painful body parts [23]. Participants were asked to identify any body parts where they had experienced physical difficulty over the last year. Difficulty was defined as any aches, pains, discomfort, numbness or tingling which had affected their normal activity or changed their daily routine for more than one day. Participants answered "yes" or "no" for each listed body part (head &neck, upper back, lower back, one or both shoulders, one or both elbows, wrists & hands, one or both groins and hips, one or both thighs, one or both knees, one or both shins, one or both calves, one or both ankles, feet). Validity testing of the NMQ as a musculoskeletal tool, found sensitivity ranged between 66-92% and specificity between 71-88% [23].

Profile of Mood States (POMS)

The original POMS is a 65-item inventory of six-subscales [24]. Due to time constrains, only three subscales of tension-anxiety, anger-hostility and confusion-bewilderment were used for this study. Participants rated "How have you felt over the past week?" for each mood descriptor i.e. "panicky". Responses were provided on a five-point likert scale (0=not at all, 1=a little, 2=moderately, 3=quite a bit, 4=extremely). Validation studies in athletic population samples have reported internal consistency (alpha) coefficients for the POMS subscales ranging from 0.72 to 0.84 [25].

Depression Anxiety Stress Scale (DASS)

The DASS includes three self-report seven-item scales designed to measure the negative emotional states of depression, anxiety and stress [26]. The stress subscale of the DASS was used, which assesses difficulty relaxing, nervous arousal, being easily upset/agitated, irritable/over-reactive and impatient. Participants were asked on a four-point scale, the rate to which they have experienced each state over the past week. The reliability (internal consistency) of the DASS-21, for the stress subscale is reported as 0.90 [26].

Coping Strategies Questionnaire (CSQ)

Catastrophising was measured using the catastrophising subscale of the CSQ. The CSQ consists of eight six-item subscales that measure the frequency of participants' use of pain coping strategies[27]. Each item (i.e. "I worry all the time whether the pain will end") is rated on a 0-6 point scale of strategy use which ranges from "never" to "always". Reliability

studies of the CSQ show internal consistency with Cronbach's alphas ranging from 0.69-0.84 [27].

Statistical analysis

Descriptive statistics are reported using mean ± standard deviation (SD) for symmetrically distributed variables, median (interquartile range) for skewed variables and percentage for categorical variables. The distributions of all numeric variables were assessed for skewness using formal tests of normality and through visual inspection of histograms.

Responses on the PSQI scale were recoded to two groups: PSQI ≥5 (poor sleep) and PSQI <5 (good sleep). The measures of subjective wellbeing were found to positively skewed and between group differences were tested using the Mann-Whitney U test. Effect sizes (ES) were computed using ES = $z/\sqrt{n}$, where z = Mann-Whitney test statistic and, interpreted using Cohen (1988) criteria of 0.1 = small effect, 0.3 = medium effect and 0.5 = large effect. Statistical analyses were performed using IBM SPSS® Statistics V21 and a 5% level of significance was used. No adjustment was made for multiple testing

Results

Total poor sleep

47.8% (n=33) of this group of elite GAA athletes were classified as "poor sleepers" and 52.2% (n=36) were classified as "good sleepers" using the PSQI, where PSQI≥5 = poor sleep and PSQI<5 = good sleep.

Self-reported sleep duration

Self-reported sleep duration for the cohort was 7.5±0.6 hrs. Self-reported sleep duration for poor sleepers was 7.3 hrs ±0.7 and for good sleepers was 7.6±0.5.hrs.

Components of the PSQI

63.7% of poor sleepers took >30 minutes to fall asleep, compared to 5.6% of good sleepers (Table I). 91.7% of good sleepers had a sleep efficiency of ≥85% compared to 39.4% of poor sleepers. 61.1% of good sleepers reported zero daytime dysfunction, compared to 18.2% of poor sleepers (Table I).

Bed-times and get up times

69.5% (5.6 + 16.7 + 47.2) of good sleepers were in bed by 11pm compared to 42.4% of poor sleepers (Table II).

Sleep Disturbances

60.6% (36.4+24.2) of poor sleepers reported that they could not get to sleep within 30 minutes, two to three times per week, compared to 5.6% of good sleepers (Table III).

Poor sleep and wellbeing

Poor sleepers had significantly increased subjective health complaints (SHC) (p=0.029), increased stress (DASS) (p=0.035) and increased confusion-bewilderment (POMS subscale) (p=0.005) (Table I), with medium effect sizes. No other wellbeing measures were significantly different between good and poor sleepers (Table IV).

Table I Components of PSQI Comparing Poor Vs Good Sleepers

		PSQI			
		Poor Sleeper		**Good Sleeper**	
		n	%	n	%
Sleep Quality	Very Good	1	3.0%	11	30.6%
	Fairly Good	22	66.7%	25	69.4%
	Fairly Bad	9	27.3%	0	0.0%
	Very Bad	1	3.0%	0	0.0%
Sleep Latency	<= 15mins	2	6.1%	14	38.9%
	16 - 30 mins	10	30.3%	20	55.6%
	31 - 60 mins	**16**	**48.5%**	**2**	**5.6%**
	> 60 mins	**5**	**15.2%**	**0**	**0.0%**
Sleep Duration	≥7 hrs	21	63.6%	35	97.2%
	≥6 - 7 hrs	9	27.3%	1	2.8%
	<6 hrs	2	6.1%	0	0.0%

	< 5 hrs	1	3.0%	0	0.0%
Sleep Efficiency	≥85%	**13**	**39.4%**	**33**	**91.7%**
	75 - 84%	14	42.4%	3	8.3%
	65 - 74%	5	15.2%	0	0.0%
	< 65%	1	3.0%	0	0.0%
Sleep Disturbances	0	0	0.0%	5	13.9%
	1 - 9	27	81.8%	31	86.1%
	10 - 18	**6**	**18.2%**	**0**	**0.0%**
	19 - 27	**0**	**0.0%**	**0**	**0.0%**
Sleep Medications	None	30	90.9%	36	100.0%
	less than once per week	2	6.1%	0	0.0%
	Once or twice a week	0	0.0%	0	0.0%
	3 or more times a week	1	3.0%	0	0.0%
Daytime Dysfunction	0	**6**	**18.2%**	**22**	**61.1%**
	1-2	15	45.5%	13	36.1%
	3-4	10	30.3%	1	2.8%
	5-6	2	6.1%	0	0.0%

PSQI=Pittsburgh Sleep Quality Index

Table II Bed-times and Get-up Times between Poor and Good Sleepers

		PSQI			
		Poor Sleeper		Good Sleeper	
		n	%	n	%
Bed-time	**22:00**	0	0.0	2	5.6
	22:30	4	12.1	6	16.7
	23:00	10	30.3	17	47.2
	23:30	6	18.2	4	11.1
	00:00	10	30.3	7	19.4
	≥01:00	3	9.1	0	0.0

Get-up time	**≤06:00**	0	0.0	2	5.6
	06:30	1	3.0	3	8.3
	07:00	5	15.2	6	16.7
	07:30	8	24.8	8	21.2
	08:00	5	15.2	7	19.4
	08:30	4	12.2	5	13.9
	9:00	5	15.2	4	11.2
	09:30-11:00	5	15.2	1	2.8

PSQI=Pittsburgh Sleep Quality Index

Table III Sleep Disturbances in Poor and Good Sleepers

		PSQI			
		Poor Sleeper		**Good Sleeper**	
	Code	n	%	n	%
Cannot get to sleep within 30 minutes	0	5	15.2%	19	52.8%
	1	8	24.2%	15	41.7%
	2	**12**	**36.4%**	**2**	**5.6%**
	3	**8**	**24.2%**	**0**	**0.0%**
Wake up in the middle of the night or early morning	0	8	24.2%	14	38.9%
	1	7	21.2%	10	27.8%
	2	11	33.3%	9	25.0%
	3	7	21.2%	3	8.3%
Have to get up to use the bathroom	0	6	18.2%	13	36.1%
	1	10	30.3%	10	27.8%
	2	9	27.3%	11	30.6%
	3	8	24.2%	2	5.6%
Cannot breathe comfortably	0	27	81.8%	36	100.0%
	1	4	12.1%	0	0.0%
	2	2	6.1%	0	0.0%
Cough or snore loudly	0	27	81.8%	32	88.9%
	1	0	0.0%	2	5.6%
	2	3	9.1%	1	2.8%
	3	3	9.1%	1	2.8%
Too hot	0	21	63.6%	29	80.6%

	1	9	27.3%	4	11.1%
	2	2	6.1%	2	5.6%
	3	1	3.0%	1	2.8%
Too cold	0	24	72.7%	32	88.9%
	1	6	18.2%	4	11.1%
	2	2	6.1%	0	0.0%
	3	1	3.0%	0	0.0%
Have bad dreams	0	28	84.8%	30	83.3%
	1	2	6.1%	3	8.3%
	2	3	9.1%	3	8.3%
	3	0	0%	0	0%
Have pain	0	25	75.8%	36	100.0%
	1	8	24.2%	0	0.0%
	2	0	0%	0	0%
	3	0	0%	0	0%

PSQI= Pittsburgh Sleep Quality Index. Code; 0=not during the past month, 1=less than once a week, 2=once or twice a week, 3=three or more times a week

Table IV Measures of Subjective Wellbeing in Poor and Good Sleepers

	Sleep			
	PSQI ≥5 "poor sleeper" (n=33)	**PSQI >5 "good sleeper" (n=36)**		
	Median (IQR)	**Median (IQR)**	**p-value**	**ES**
SHC	1 (0-4)	0.5 (0-2)	0.029*	0.26
NMQ	1 (1-3)	2 (1-3)	0.052	0.23
DASS-stress	10 (4-12)	4 (2 -10)	0.035*	0.25
CSQ	1 (0-3)	0 (0-2.5)	0.287	0.13
POMS	5 (2-8)	3 (1-5)	0.059	0.23
Anger-hostility	1 (0-4)	1 (0-2)	0.346	0.11
Tension-anxiety	0 (0-3)	1 (0-2)	0.593	0.06

Confusion-bewilderment	1 (0-3)	0 (0-0)	0.005*	0.34

PSQI (Pittsburgh Sleep Quality Index) SHC (Subjective Health Complaints), NMQ (Nordic Musculoskeletal Questionnaire), DASS (Depression Anxiety Stress Scale), CSQ (Coping Strategies Questionnaire), POMS (Profile of Mood States) total of three subscales. Mann-Whitney U test, * $p<0.05$, ES = Effect Size

Discussion

The aims of this study were to measure the sleep profile of elite GAA athletes and to examine if there was a relationship between poor sleep and subjective wellbeing measures. The main findings of this study indicate 47.8% of elite GAA athletes are poor sleepers with significantly increased subjective health complaints, increased stress and increased confusion compared to good sleepers. However, there were no significant differences between poor and good sleepers for subjective wellbeing markers of; number of painful body parts, catastrophising, overall mood and subscales of tension-anxiety and anger-hostility. Self-reported sleep duration in this sample of elite GAA athletes was 7.5 ± 0.6 hrs sleep per night.

Poor sleep in elite athletes

The sleep profile of GAA athletes in this study is highly comparable to a study of 175 elite rugby and cricket players which reported 50% of their athletes to be poor sleepers as classified using the PSQI [16]. A study of 124 elite Australian athletes recorded 6.8±1.1 hrs sleep per night using actigraphy [15] which is slightly lower than that reported in the current study (7.5±0.6hrs). Differences may relate to different sports, and the use of different outcome measures of daily sleep diaries and wrist actigraphy in the Australian cohort. Although, sleep is reported as the most important method of recovery by athletes (Venter 2014) it appears that a significant proportion of athletes are getting poor sleep. A recent sleep study on 107 professional ice hockey players reported that one in four of their sample had a clinical sleep disorder such as obstructive sleep apnoea or insomnia [28]. Outside of clinical sleep disorders, some factors cited as contributing to poor sleep in athletes include; early morning training sessions[29], pre-competition stress[30, 31], both short [32] and long-haul travel [32-34] and night-time competition [6, 29].

Sleep and lower general health

Elite Gaelic athletes who were poor sleepers (47.8%) had significantly increased subjective health complaints. The SHC covers frequent reasons for an encounter with a

general practitioner and thus can be considered an indicator of overall general health [22]. The elite athletes with poor sleep had lower overall general health profiles. This is consistent with the literature which reports the links between poor sleep and immune system dysfunction. Poor sleep is associated with a range of chronic illnesses [3], increased susceptibility to infections [1], and even premature mortality [2]. A five-year prospective study of international track and field athletes reported that training interruptions due to illness or injury are associated with a significantly lower chance of achieving pre-defined performance goals [35] highlighting the obvious importance of keeping athletes fit and healthy. Poor sleepers in the current study reported a mean sleep duration of 7.3 ± 0.7 hours which was very similar to good sleepers who reported 7.6 ± 0.5 hours of sleep per night. Sleep duration alone may be insufficient to identify athletes at risk of lower general health. Research in non-athletic samples have reported that shorter sleep duration (<six hours) significantly increases the risk of contracting the common cold [36]. Conversely, a recent systematic review found that sleep disturbance and long sleep duration, not short sleep duration, was associated with increased systemic inflammation [37], highlighting the complexity of sleep, and the potential limitations of using sleep duration alone as a cut-off score for optimal general health.

Poor sleep and decreased mood

In this study, poor sleepers had significantly decreased mood on the POMS subscale of confusion, but overall mood, anger, and tension were not significantly different between good and poor sleepers. Similarly a study of 277 elite volleyball players found that self-reported poor sleep quality was significantly associated with higher scores for confusion (Brunel Mood Scale) compared to those reporting good sleep quality [38]. A large study of 1125 university students (17-24 years) reported that poor sleepers (PSQI) had significantly greater negative mood subscale scores (anger, confusion, depression, fatigue, and tension), compared to good sleepers [39]. The difference across all mood states may relate to a lower PSQI cut-off score, the use of only three POMS subscales for feasibility purposes and the smaller sample size in the current study. The POMS has traditionally been used in athletes to measure pre-competition mood to predict athletic performance [40] and more recently, fluctuations in mood (i.e. POMS) have been reported as reflective of acute changes in training load, identifying athletes possibly at risk of overtraining [13]. A study of 103 athletes reported that 70% experienced poor sleep that night before competition and this had a significant negative effect on subsequent mood but not performance [5]. The influence of poor sleep on mood

should be noted when considering mood as a reflective of overtraining or predictive of performance.

Poor sleep and increased stress

In this study, poor sleepers reported significantly greater stress compared to good sleepers. Increased levels of stress are reported in athletes pre-competition and are associated with poor sleep [33]. The bidirectional relationship of increased stress and poor sleep is widely acknowledged [41] with a large study on stress and university students reporting that increased stress was the strongest predictor of poor sleep quality [39]. A systematic review of elite sport and sleep quality [32] proposed that some of the psychological traits of elite athletes, such as perfectionism, may predispose them to poor sleep quality and/or insomnia [41]. Monitoring stress is reported as a sensitive measure of acute changes in training load, which can be important for identifying athletes at risk of overtraining [13]. Poor sleep should be taken into consideration when interpreting stress monitoring data, due to the transactional relationship between these two variables. Recently, there has been a surge in popularity of wearable technology to self-monitor sleep however the validity of these tools and unknown stress of continuous sleep monitoring and timing of electronic device usage have been questioned [42] therefore recommendations on their usage cannot be given.

Poor sleep and pain

There was no difference in pain as measured using NMQ between good and poor sleepers in this study. This finding differs from a study on 452 elite athletes that found a significant difference between poor sleepers and good sleepers (PSQI) and number of painful body parts (NMQ) [43]. The larger sample size and inclusion of female athletes (61.1%) may possibly account for the differences in their study as higher levels of sleep disturbances are reported in female athletes [44]. There may also be issues when comparing the PSQI, which has one month recall and the NMQ, which as a one year recall.

Implications of poor sleep in elite GAA athletes

In the current study, athletes with poor sleep profiles had increased subjective health complaints, increased stress and decreased mood of confusion compared to athletes with good sleep profiles. Poor sleep has also been associated with an increased risk of injury in adolescent athletes [45] however it is unknown if this risk exists in adult athletes. A recent review presents an interesting over-view of the interaction between sleep, sport and the brain, and how this may influence athletic performance [46]. Poor sleep has been shown to negatively affect cognitive function and psychomotor performance [47]. Sleep restriction has also been shown to decrease speed of impulses from the brain to the working muscles, affecting reflex and reaction times [48]. GAA athletes who need to make fast accurate decisions and execute high level skills may be negatively affected by poor sleep. Poor sleep has also been shown to compromise other areas of cognition such as memory consolidation and learning new skills [49, 50]. It is possible that athletes' ability to learn new skills and retain new memories of strategies are compromised by poor sleep [46].

Potential benefits of improved sleep

It is well-documented that poor sleep is associated with negative health outcomes [3] but the effect of improved sleep is less conclusive [51]. Epidemiological studies report that sleep durations of >eight hours is associated with poor general health outcomes such as increased cardiovascular risk and mental health problems [3], although these findings are more representative of older population with failing health who spend greater time in bed but may not have longer sleep time [52]. A six-week sleep intervention study on Australian Rules footballers reported improvements in sleep efficiency, decreased fatigue and increased vigour [18]. Studies on college basketball players where their sleep was extended to ten hours sleep/night resulted in; increased sprint times, improved reaction times and improved mood compared to controls after a period of 6 weeks [53]. Although these are attractive outcomes, the logistics and reproducibility of these interventions may prove difficult. It is important to note that poor sleep (too little and too much) is associated with adverse health outcomes [3], but it is not a conclusive causative risk factor for decreased health, and thus manipulation of sleep may not automatically result in reversal of poor health [51]. It is plausible that the optimum amount of sleep for athletes is an individual requirement and it may be potentially stressful for athletes to be given a set number of hours of sleep per night when their sleep history, profile and requirements will most likely be individual.

While the importance of sleep is generally acknowledged within the sports team environment [7], it is unclear which member of the backroom team is responsible for assessment, monitoring and intervention in the sleep profiles of athletes. Identifying a specific person within the backroom team may help with implementation of positive sleep education [13]. A study of 107 professional ice hockey players reported positive outcomes in sleep quality after a two-hour sleep counselling intervention [28]. It is noted that clinical sleep disorders such as obstructive sleep apnoea and insomnia required specialist intervention. Therefore, identification of clinical sleep disorders is important as these individuals may be unresponsive to general sleep counselling.

Limitations

This was a male only, cross-sectional study with a relatively small sample size. The athletes in this study are from two highly specialised sports (hurling, gaelic football) and therefore the findings may not be generalisable- to athletes from other sports. Sleep was assessed using subjective measures only. Objective sleep measures provide greater diagnostic accuracy of sleep architecture and screening for sleep disorders [54]. The retrospective nature of our outcome measures may be subject to recall bias. The NMQ has a recall period of one year, which is much longer than that of the other outcome measures used which were between one week and one month. This may have influenced our findings on the relationship between sleep and pain. Only three subscales of the POMS were used in order not to overburden the participants, however the subscales of fatigue-vigour, anger-hostility and depression would have been interesting to analyse in relation to sleep. No adjustment was made for multiple testing which may increase the risk of type I error in our findings. It is plausible that these athletes with poor sleep, may represent a group of individuals with a collection of symptoms of common, mild, mental health disorders as documented in a recent prospective study of elite Gaelic athletes [55]. A causal relationship cannot be interpreted from our findings as this is an observational study and the reciprocal relationship between poor sleep and subjective wellbeing is acknowledged.

Conclusion

Results of this study indicates nearly 50% of elite GAA athletes report getting poor sleep. There is a significant relationship between poor sleep and increased subjective health complaints, increased stress and decreased mood of confusion and these factors may all relate to each other. The interaction between these measures is not fully understood and further

research into this relationship is advocated. Sleep is important and is the main method of recovery in athletes. It is recommended that sleep is assessed in athletes. General sleep education may be adequate for some athletes however other athletes may require more specialist intervention for sleep problems.

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