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Chronotype and quality of sleep in alpine skiers

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ABSTRACT

Alpine skiing is among the most demanding sporting activities in terms of physical effort and mental workload. The aim of the study was to compare sleep quality and chronotype distribution between 84 highly trained alpine skiers and a control sample of 84 non-athletes matched by age and sex ratio. Quality of sleep was assessed by the Pittsburgh Quality of Sleep Index (PSQI), and chronotype was assessed by the Morningness-Eveningness Questionnaire (MEQ). Additional questions assessed sleep management during training or competitions. The results showed a marked skewed chronotype distribution towards morningness in alpine skiers (52.4% morning type, 42.8% intermediate, and 4.8% evening type) in comparison to the control group. The midpoint of sleep was significantly anticipated among alpine skiers. Differently from the previous literature that showed poor sleep quality and quantity in competitive athletes, the quality and quantity of sleep in alpine skiers was within the normal range in all the PSQI subcomponents.

Alpine skiing is among the most physically and cognitively demanding sporting activity, pushing the athletes to the limits, both mentally and physically, due to the high speed, the ability to swiftly turn between the gates, the necessity to memorize the course that changes from one competition to the next, and also between the first and the second run of a same competition. Besides, athletes need to adapt quickly to changing snow and/ or weather conditions. The time gap between the participants in an international competition is measured in hundredths of a second, and the athletes' performance is compressed into a few seconds. So far it has been neglected in scientific research and this is the first study that focuses on alpine skiers, focusing on their chronotype and sleep.

Success in such a demanding sport requires a very strong self-discipline in sleep hygiene in order to maintain a high level of alertness and to achieve good physical and mental recovery from training sessions and competitions. The aim of this study was to assess chronotype distribution and sleep quality in alpine skiers. Sleep has numerous important physiological and cognitive functions that may be particularly important to elite athletes (Cirelli and Tononi 2008; Dattilo et al. 2011). Sleep has been recognized as an essential component of recovery from (and preparation for) highly intensive training (Albouy et al. 2013; Reilly and Edwards 2007; Robson-Ansley et al. 2009; Samuels 2008; Walker and Stickgold 2005). Recently, Charest and Grandner (2020)

have underlined the key role of sleep for athletic performance, cognition, health and psychological well-being (Charest and Grandner 2020).

Specifically, we compared the chronotype and quality of sleep in a sample of alpine skiers with a control group of non-athletes. Quality of sleep was assessed with the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al. 1989), which includes quantitative aspects of sleep, such as sleep duration, sleep latency, number of arousals, as well as more subjective aspects of sleep such as "sleep depth" or "restfulness from sleep." Previous research has usually highlighted a poor sleep quality and quantity in most elite athletes, regardless of the type of sport (Bender et al. 2018; Drew et al. 2018; Hoshikawa et al. 2018; Lucidi et al. 2007; Mah et al. 2018; Samuels 2008; Turner et al. 2021). Samuels (2008) found that more than 55% of athletes in the Bobsleigh Canada Skeleton team were poor sleepers. Fietze et al. (2009) observed a poor sleep quality in 50% of a sample of 24 professional ballet dancers. The same percentage was found by Swinbourne et al. (2016) in a sample of 175 elite rugby and cricket athletes. Tuomilehto et al. (2017) found that 25% of professional ice hockey players were poor sleepers.

The recommended amount of sleep for adults is between 7 h and 9 h per day (Consensus Conference Panel 2015). According to the available evidence, many athletes from different sports do not meet the minimum sleep quantity recommendation (Lastella et al. 2015; Leeder et al. 2012; Sargent et al. 2014). Specifically, the

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study of Leeder et al. (2012) documented in 47 Olympic athletes an average of 6.9 h of sleep across four nights, as measured objectively by actigraphy. Knufinke et al. (2018) investigated the sleep quantity and quality in 98 elite young athletes competing at the highest international level and found that 41% of all athletes could be classified as poor sleepers and that 12% were identified as having a sleep disorder. In the study of Swinbourne et al. (2016) on 175 elite and highly trained rugby and cricket athletes, 50% of them were found to be poor sleepers, with a high prevalence of daytime sleepiness. The study of Hrozanova et al. (2018) was more related to winter sports. It assessed habitual sleep patterns of 31 junior elite athletes in cross-country skiing and biathlon over a period of up to four consecutive months. The athletes obtained on average 7.21 h of sleep per night, with an average sleep efficiency of 89.5%.

In addition to sleep quality, chronotype distribution was assessed in alpine skiers and controls. Chronotype refers to individual differences in the timing of the sleep/wake schedule (Adan et al. 2012) and is strictly linked to the circadian fluctuation of basal body temperature (Lack et al. 2009) and timing or phase differences in the endogenous biological rhythm (Horne and Ostberg 1977; Kerkhof et al. 1980). Morning-type individuals have earlier sleep-wake schedules, earlier diurnal peaks of alertness and performance and earlier sleep propensity rhythms than evening-type individuals (Adan and Natale 2002; Adan et al. 2012). The natural light/dark cycle and normal schedules tend to best suit the lifestyle of morning types, which tend to maintain a more regular sleep/wake schedule in comparison to evening-type individuals (Roepke and Duffy 2010). Normative data on chronotype distribution among the general adult population (19–31 years old) indicate a normal distribution, with intermediate types occurring in 70% of cases, morning types in 14% of the population, and evening types in 16% of the population (Rosenthal et al. 2001).

Evidence suggests that chronotype has a significant impact on cognitive performance and physical activity in sports. Most current research suggests that the best athletic performance occurs in the late afternoon-early evening, matching the peak of core body temperature (Kline et al. 2007). In contrast, sport performance is suggested to be impaired when core body temperature is at its lowest (Waterhouse et al. 2005). Teo et al. (2011) have shown that higher core body temperature tends to facilitate actin-myosin cross bridging in skeletal muscles. Other studies have shown that muscular strength, regardless of the muscle group, peaks in the late afternoon/early evening. A similar trend has also been reported for anaerobic exercise and short-term power (see Rosenthal et al. 2001).

Accuracy, along with measures of fine motor control, has been reported to be better in the morning (Atkinson and Speirs 1998). Other skills investigated in tennis, swimming and soccer have been shown to be better in the afternoon or evening (Thun et al. 2015). Facer-Childs et al. (2018) measured cognitive and physical performance in early and late chronotypes at various times of day and found different diurnal variation profiles between early and late types for daytime sleepiness, psychomotor vigilance, executive function and isometric grip strength. Early chronotypes performed better than late chronotypes across all performance measures in the morning.

Several studies exploring chronotype in athletic individuals indicate that there is an overrepresentation of morning-types. For example, Silva et al. (2012) found that 71% of Brazilian paralympic athletes were classified as morning-types. Similarly, Kunorozva et al. (2012) found that 72%, 67%, and 59% of well-trained South African male cyclists, runners, and Ironman triathletes, respectively, were also classified as morning types. These results have been replicated in further studies of well-trained individual athletes (Henst et al. 2015; Lastella et al. 2010; Rae et al. 2015), and suggest that athletic groups contain a higher proportion of morning-types than what is typically found in the general population.

Lastella et al. (2016) found no differences in the chronotype distribution of athletes from cricket, hockey, soccer, and cycling compared to the chronotype distribution in non-athletes. They found a significantly higher proportion of triathletes that were morning and intermediate types compared to a control population. This supports the notion that athletes tend to pursue and perform better in sports that match their chronotype (Kunorozva et al. 2012; Rae et al. 2015; Zani et al. 1984). Of the 114 athletes considered in Lastella et al. (2016), 28 were classified as morning types, with 72% of morning types involved in morning sports. A closer look at the data suggests that chronotype distribution in athletes may be dependent on the type of sport, with differences between team and individual sports as was also highlighted by Zani et al. (1984).

Training time is another key factor to successfully match the chronotype to the selected sport. Elite athletes practicing "morning sports," like golf, tend to be morning types, while elite athletes involved in "evening sports," like volleyball, are mostly evening types (Mulè et al. 2020). A differentiation of chronotype according to the type of sport was also found by Kentiba et al. (2020): players who participated in skill, concentration, and mixed sport events were predominantly intermediate types, while those who participated in football and athletics were predominantly evening types.

The influence of chronotype is not only limited to the perceived workload but also to the actual performance. Rae et al. (2015), in a study on swimmers, showed a significant diurnal variation in performance as a function of chronotype. In the same line, Brown et al. (2008) highlighted an interaction between chronotype and rowing speed in a group of 16 collegiate rowers.

Specifically related to winter sport athletes, a previous research by Bender et al. (2018) has investigated subjective sleep quality and chronotype in a group of 63 national and Olympic winter team athletes competing in bobsleigh, cross-country skiing, long-track speed skating, skeleton, luge, biathlon, short track speed skating, ski cross, and curling. They found athletes had poor sleep quality. Besides, their chronotype distribution showed a greater skew toward morningness. Although the athletes included in the Bender et al. (2018) study practiced winter sports, the physical and psychological demands of the disciplines included in that study differ significantly from those required for alpine skiing. For example, cross-country skiing and long-track speed skating are mainly enduring competitions, while in skeleton, luge, bobsleigh, and curling, physical workload is much lower than in alpine skiing.

The aims of the study were to investigate chronotype distribution and sleep quality in alpine skiers during competitions. Alpine skiing is an individual sport with training sessions mainly concentrated during the morning and early afternoon. So, given the high physical and mental demand of this sport, the hypothesis was that alpine skiers would exhibit a chronotype distribution strongly skewed toward morningness and that the quality and quantity of sleep in alpine skiers would be more problematic than in a matched control population of non-athletes.

Method

Participants

Participants were 168 divided in 84 alpine skiers (experimental group) and 84 non-athletes matched for age and sex-ratio to alpine skiers (control group). The 84 alpine skiers were officially enrolled in the Italian Federation of Winter Sports (FISI *Federazione Italiana Sport Invernali*) and were competing or training for a world, European, national, regional or provincial alpine skiing competition at the time of their participation in the study. Athletes competing at the national and international levels were also enrolled in the FIS (*International Ski Federation*) circuit.

The distribution of the different levels of competitions was as follows: FIS Alpine Ski World Cup: 11.9%, FIS Alpine Ski Europa Cup: 13.09%, FIS national competitions (Italy): 30.95%, FISI regional competitions: 39.28%, FISI provincial competitions: 4.76%. Forty-eight athletes were males (M_{age}: 23.92, *SD*: 12.60), and 36 were females (M_{age}: 20.25, *SD*: 8.40). Twenty-nine athletes (34.52%) practiced at a professional level (alpine skiing as the only occupation).

With reference to specialization, 61.9% of the athletes was specialized in technical disciplines (i.e., slalom and giant slalom), 5.95% of participants was specialized in speed disciplines (i.e., Super-G and downhill), and 32.14% were specialized in both speed and technical disciplines. Mean years of practice were 12.14 (*SD* = 8.29).

The training routine differs quite heavily according to the level of competition, however it normally includes a two to three-hour training in the morning and a training in the early afternoon. Sometimes, the afternoon training is not outdoors, it includes muscle potentiation and video analysis. The number of training days depends on the level of competition, ranging from 2 or 3 days a week for those competing at the FISI provincial and regional level to 6 days a week for those engaged in FIS national, European, and world competitions.

Participants were contacted through official instructors of the FISI association. Participation was on a voluntary basis and each participant digitally signed an informed consent prior to the participation. As far as minors were concerned, both parents' informed consent was requested. The procedure of the study was approved by the Ethics Committee of the University of Bologna (Ref number 0299302).

The control group was composed of 48 males (M_{age} = 23.83, *SD* = 3.74) and 36 females (M_{age} = 22.72, *SD* = 4.93). It was made up of university students (65.48%) and young professionals/workers (34.52%). They were recruited on a voluntary basis: the students were enrolled in psychology courses, and the professionals/workers were relatives or acquaintances of the university students. A prerequisite for entering the control group was not to practice any sport at a competitive level.

A posteriori power analysis was performed with G*Power (Faul et al. 2007), considering a two-group ANOVA, a total sample of 168 participants, an alpha level of .05, and an expected effect size of 0.25, the total power was 0.90.

Materials

Chronotype was assessed by the *Morningness-Eveningness Questionnaire* (MEQ) (Horne and Ostberg 1976) in its Italian version (Mecacci and Zani 1983).

MEQ is the most widely used self-assessment questionnaire for the evaluation of individual circadian rhythm. It consists of 19 items to assess preferred time for waking up, going to sleep, and exerting physical or mental activities.

From the analysis of MEQ answers, it is possible to compute important chronobiological indexes such as the midpoint of sleep, which is defined as the clock time between sleep onset and wake-up time, and the desired total sleep time. The midpoint of sleep is considered a useful marker of chronotype (Zavada et al. 2005).

Quality of sleep was assessed by an adaptation of the *Pittsburgh Sleep Quality Index* (PSQI) (Buysse et al. 1989) in its Italian version (Curcio et al. 2013). The questionnaire is composed of 19 items that assess sleep quality and quantity in the last month. In the alpine skiing sample, the sentence "During the last month" was replaced with "During the last month when I took part in alpine skiing competition," since the aim was to focus on quality of sleep during competitions. Dependent variables were global score, subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, daytime dysfunction, perceived sleep quality, and sleep efficiency.

In the athlete group, besides the MEQ and PSQI, the procedure included a set of questions specifically related to sleep management during sport competitions and a set of general questions related to competition level. Specifically, the questions were as follows: (a) Number of years of participation in alpine skiing competitions; (b) Level of competitions (FIS Alpine Ski World Cup, FIS Alpine Ski Europa Cup, FISI national, FISI regional, FISI provincial); (c) Specialization (slalom, giant slalom, super-g, downhill); (d) Practice at professional level (yes/no); (e) Difficulty in falling asleep due to competition anxiety (4-points, from almost never to very often); (f) Having a lot on your mind the night before a competition (4-points, from almost never to very often); (g) Waking-up frequently during the night before a competition (4-points, from almost never to very often); (h) Feeling poorly rested at wake-up time the morning before a competition (4-points, from almost never to very often); (i) Comparison of sleep quality during competitions and outside competitions (5-points, from much worst to much better); (j) Preferred wake-up time during training, being free to plan the training when desired; (k) Preferred time for going to sleep during training whenever free to do it; (l) Discrepancy between preferred wake-up time and actual wake-up time during training (4-points); (m) Preferred time of the day for a competition; (n) Having received information by the trainer or the sport society on sleep management during training or competitions (yes/no); (p) Self-assessment of the importance of sleep during alpine ski performance (4-points); (q) Self-assessment of the importance of sleep management seminars and/or guidelines organized and delivered by the coach or the sport society (4-points).

Procedure

Selected participants were given a *Qualtrics* link to take part in the research. The study was run during the winter season during competitions. The materials were organized along this sequence: presentation of the study, request to digitally sign an informed consent, sociodemographic information (sex, age), MEQ, PSQI, set of questions about the technical level and the skier's specialization in the different disciplines related to alpine skiing (alpine skiers only), and set of questions about sleep management during training and competitions (alpine skiers only). For the control group, only sociodemographic information, MEQ, and PSQI were included.

The complete sequence took 20 min on average. Participation was anonymous, and no personal data were collected.

Data analysis

Shapiro–Wilk test was used for testing normality of the distributions of MEQ, PSQI, and midpoint of sleep. MEQ data were normally distributed, and the difference between alpine skiers and control participants was tested with a univariate ANOVA. Midpoint of sleep and PSQI data were not normally distributed, and the effect of group was tested with Mann–Whitney nonparametric test.

The association between preferred time for competition and MEQ score was tested with a linear regression. All statistical analyses were performed with IBM SPSS v. 29.

Results

MEQ

Mean MEQ score was 57.30 ($SD = 7.91$) for alpine skiers and 47.12 ($SD = 10.46$) for control participants. The univariate ANOVA that tested the difference between the two groups was significant: $F(1, 164) = 450.518$, $p < .001$, $\eta^2 = 0.23$. The distribution of MEQ scores for the two groups is shown in Figure 1. The Shapiro–Wilk test of normality was significant neither for both alpine skiers nor for control ($W = .97$, $p = .06$, and $W = .99$, $p = .74$, respectively). The difference
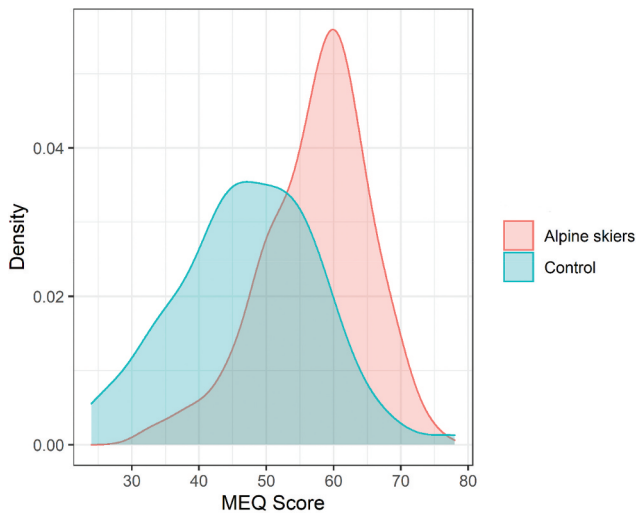
Figure 1. Distribution of MEQ score in alpine skiers and control participants.

Figure 2. Distribution of midpoint of sleep in alpine skiers and control participants.

between male and female athletes was not significant ($p = .82$). The effect of the competition level was also non-significant ($p = .48$).

The alpine skiers group exhibited on average a high MEQ score that indicated high levels of morningness. Categorizing the MEQ scores into morning, intermediate, and evening chronotypes, the alpine skier population consisted of 52.4% morning types, 42.8% intermediate types, and 4.8% evening-type athletes. The control group was made up of 11.91% morning type, 59.52% intermediate, and 28.57% evening type.

Midpoint of sleep

The alpine skier sample had an average midpoint of sleep of 3.60 ($SD = 0.70$). The control group had an average midpoint of sleep of 4.65 ($SD = 1.43$). The distribution of midpoint of sleep in the skier and in the control sample is shown in Figure 2. The Shapiro-Wilk test of normality was significant for both groups ($W = .93$, $p < .001$ for alpine skiers, and $W = .88$, $p < .001$ for control participants), showing a significant deviation from normality. Specifically, the distribution for alpine skiers showed an asymmetry of 1.12 (positively skewed), with a kurtosis of 3.20. In the control group, the asymmetry was 1.55, and the kurtosis was 3.28. Since midpoint of sleep data were not normally distributed, we applied a non-parametric Mann–Whitney test to independent samples. The test was significant: $U(168) = 5435.50$, $p < .001$. The median midpoint of sleep was 3.5 (SD 0.69) for alpine skiers and 4.43 ($SD = 1.43$) for the control group. The midpoint of sleep was not different between male and female participants ($p = 72$).
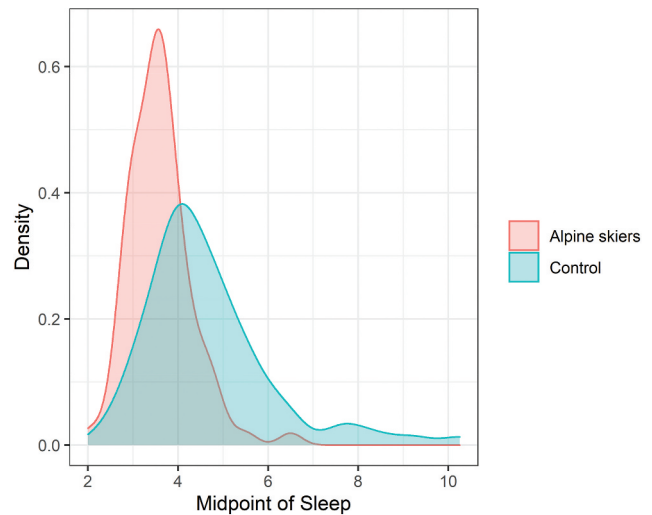
The distribution of midpoint of sleep further corroborated the results of the MEQ, showing a shift toward "morningness" in alpine skiers. The MEQ and midpoint of sleep exhibited a significant Pearson correlation ($r = -.71$, $p < .001$).

Preferred time for competitions

The mean preferred time for competition was in mean 10:07 h ($SD = 0.95$). A linear regression tested the relation between preferred time for competitions and the MEQ score. The regression model was significant: $F(1, 82) = 22.74$, $p < .001$, $R^2 = .21$. The regression coefficient ($B = -0.056$ CI $[-0.08-0.03]$) indicated that a one-point increase in the MEQ resulted in a 3-min 21-s decrease in preferred time for competition.

PSQI

PSQI global score distributions for both alpine skiers and control participants are reported in Figure 3. A Shapiro–Wilk test showed that the distribution was not normal for either groups ($W = .89$, $p < .001$ for alpine skiers and $W = .91$, $p < .001$ for control participants). The Mann-Whitney non-parametric test for independent samples was therefore applied when testing differences between the two groups for PSQI global score and subscale scores. The comparison of the PSQI global score between alpine skiers and the control group was significant: $U(168) = 4932$, $p < .001$. Median PSQI score in alpine skiers was 4 ($SD = 2.17$), while the median PSQI score in the control group was 5.00 ($SD = 3.18$) (Figure 3).
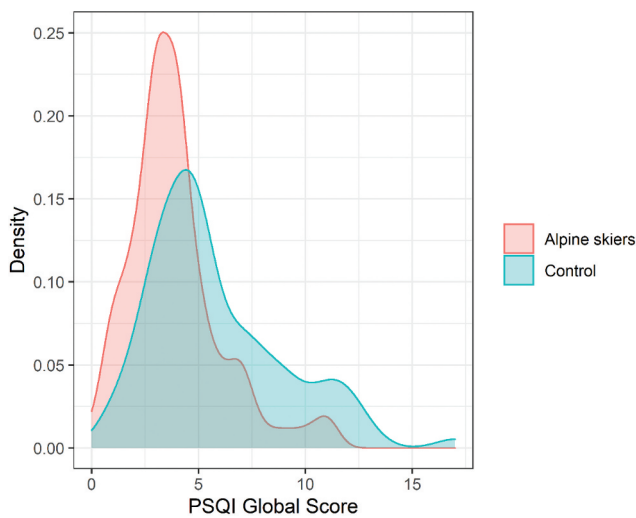
Figure 3. Distribution of the global PSQI score in alpine skiers and control participants.

The Mann–Whitney test was also applied to the seven PSQI components, as shown in Table 1. For sleep duration, sleep latency, and sleep quality, alpine skiers showed better indexes, demonstrating a better sleep quality.

Sex was not a critical factor in any of the PSQI components.

Sleep management questions (alpine skiers only)

Anxiety and difficulty in falling asleep the night before a competition

On a 1–4 scale the mean level of difficulty in falling asleep because of anxiety was 2.01 (SD = 0.83) CI [1.83 2.19].

Having a lot on your mind the night before a competition

On a 1-4 scale the question "Having a lot on your mind the night before a competition" was evaluated with a mean of 2.57 (SD = 0.90) CI [2.37 2.77].

Waking up during the night before a competition

On a 1–4 scale waking up during the night before a competition was evaluated with a mean of 1.52 (SD = 0.80) CI [1.35 1.70].

Feeling poorly rested after a night sleep the night before a competition

On a 1–4 scale the mean value to the question on feeling poorly rested after a night sleep was 1.99 (SD = 0.87) CI [1.80 2.18].

Sleep during competitions versus sleep outside competitions

On a −2 + 2 scale (5-points), the mean score was −0.52 (SD = 0.89) CI [−0.72–0.33]. A t-test that compared the distribution with a mean value of 0 was significant: $t(84) = -5.34$, $p < .001$, CI [−0.72–0.33], Cohen's $d = 0.58$, indicating a significant worsening of sleep during competitions.

Preferred waking-up/going to sleep time during training

The mean preferred wake-up time during training was 7:56 h. The preferred time for going to sleep during training was 20:34 h.

Preferred time for a competition

The average preferred time for an alpine skiing competition was 10:04 h.

Self-evaluation of the influence of sleep quality on sport performance

On a 1–4 scale, alpine skiing athletes evaluated with a mean of 3.26 (SD = 0.76) CI [3.10 3.43] the importance of sleep quality for their sport performance.

Education on sleep management

On a 0–3 scale, alpine skiers rated the amount of information in sleep management and sleep hygiene offered by the coach and/or the sport club with a mean value of 0.46 (SD = 0.68) CI [0.32 0.61].

Table 1. Comparison of PSQI components and global score between alpine skiers and control participants.

	Skier median (SD)	Control median (SD)	U	p
Sleep duration	0.00 (0.59)	1.00 (0.75)	4876	<.001
Sleep disturbance	1.00 (0.40)	1.00 (0.44)	3571	n.s.
Sleep latency	0.00 (0.79)	1.00 (1.02)	4663.5	<.001
Daytime dysfunction	1.00 (0.71)	1.00 (0.72)	4026	n.s.
Habitual sleep efficiency	0.00 (0.42)	0.00 (0.75)	3733.5	n.s.
Sleep quality	1.00 (0.55)	1.00 (0.69)	4700.5	<.001
Use of sleep medications	0.00 (0.45)	0.00 (0.65)	3657	n.s.
Global PSQI score	4.00 (2.17)	5.00 (3.18)	4932	<.001

The distribution of global PSQI score among skiers and controls is shown in Figure 3.

Request for sleep management training

On a 1–4 scale, alpine skiers evaluated with a mean of 3.17 (SD = 0.78) CI [3 3.34] the request for a sleep management education from the coach and/or the sport club.

Discussion

The study assessed the chronotype distribution and sleep quality/quantity in a sample of alpine skiers compared to a control group. The results have evidenced a marked shift toward morningness and an overall good quality/quantity of sleep in alpine skiers in comparison to the non-athletes control group.

Alpine skiers exhibited on average a higher MEQ score in comparison to non-athletes matched for age. Considering MEQ categories, 52.4% of alpine skiers were classified as morning types. The mean preferred wake-up time during training was 7:56 h. All the athletes preferred to compete during the morning hours and none indicated a time past 11:30 h as preferred time for a competition. The mean preferred time for a competition was 10:04 h, and this preference was independent of the athlete's level of performance.

Chronotype distribution in the control group was 14.91% morning type, 59.52% intermediate, and 28.57% evening type. This distribution was substantially different from that found in the sample of alpine skiers. Pivovarnicek et al. (2021), in a study on elite football players found a prevalence of morning types: 18.8% for those engaged in the First League and 24% for those in the National Football League. Interestingly, the prevalence of evening-types was very low (9.4% for football players in the first league and 1.9% for football players in the national league), in comparison to the prevalence of evening types in large-scale population study (e.g., 26.9% in BaHammam et al. 2011 16% in Rosenthal et al. 2001).

A high prevalence of morning types among elite athletes has been found in other studies (e.g., Bender et al. 2018; Kunorozva et al. 2012; Lastella et al. 2016; Samuels 2008; Silva et al. 2012). Specifically, Lastella et al. (2016) investigated the chronotype distribution in 114 athletes from five sports (cricket, cycling, hockey, soccer, and triathlon). They found an extremely low presence of evening types (6.14%) in the sample of elite athletes. The prevalence of morning types was 28.94%, reaching a peak in triathlon athletes (48%). They also found a significant relationship between sport and chronotype group, with a higher proportion of morning types involved in morning sports such as cycling and triathlon, and a higher proportion of intermediate/evening types in evening sports such as cricket, hockey, and soccer.

It is interesting to note that in Lastella et al. (2016), the sport that collected the highest prevalence of morning types was triathlon, which, between the five sports considered in that study, was the most demanding both physically and mentally. The prevalence of morning types in triathlon (49%) was very similar to the prevalence of morning types in alpine skiers (52.4%) found in this study. A higher incidence of morning types in triathlon athletes was also found by Vitale, Banfi et al. (2019). When analyzing rest-activity circadian rhythms, acrophase was significantly anticipated in triathlon athletes in comparison to soccer or volleyball athletes. In the same line, triathlon athletes had early sleep onset and offset times compared to both volleyball and soccer players (Vitale, La Torre et al. 2019). The results of these studies could suggest that skewed distribution of chronotypes toward morningness could be proportional to the physical and mental demand that a sport imposes on athletes.

Multiple factors could explain the high prevalence of morning types in many athletes. Morning-type individuals tend to maintain a more regular sleep\wake schedule compared to individuals with an evening preference (Roepke and Duffy 2010). Evening types typically tend to report a greater daytime sleepiness than morning types (Clodoré et al. 1990; Volk et al. 1994), resulting in a deleterious impact on sport performance. Furthermore, matching the chronotype to the training schedule results in better performance (Drust et al. 2005). In the specific case of alpine skiers, training and competitions normally take place in the morning and early afternoon, which suits best morning types. Athletes tend to select, pursue and excel in sports, which match their chronotype. As shown by Lastella et al. (2010) and Zani et al. (1984) athletes involved in sports with prevalent training in the morning are mostly morning types, while athletes that train and compete mostly in the afternoon and evening tend to be evening types. In addition, chronotype has specific relations with personality and motivational factors that could affect athletes' performance. For example, the evening type is more prone to addiction (Prat and Adan 2011), spending more time in front of the computer and television (Gaina et al. 2006; Urbán et al. 2011), and consuming more alcohol and nicotine (Adan 1994). Przepiórka et al. (2019) found a positive association between procrastination, low self-control, low self-efficacy and eveningness.

Alpine skiers are exposed to extreme levels of sunlight due to the highly reflective environment in which they practice their sport, and this could determine a circadian phase anticipation that matches their

prevalent morning chronotype. Exposure to sunlight increases the amplitude of the light–dark signal and questionnaire studies by Harada et al. (2002) and Roenneberg et al. (2003) have shown that morning types spend more time outdoors in bright light than evening types. Goulet et al. (2007) used ambulatory monitoring to measure 24-h light exposed in morning and evening type for 7 consecutive days. They found that, on average, morning types had higher daily bright light exposure (>1000 lx) than evening types.

While previous research has often highlighted problems in sleep quality and quantity in elite athletes (Bender et al. 2018; Drew et al. 2018; Gupta et al. 2017; Hoshikawa et al. 2018; Lucidi et al. 2007; Mah et al. 2018; Samuels 2008; Turner et al. 2021) the present research has shown an overall good quality of sleep in alpine skiers. The sample of alpine skiers had a median PSQI score of 4, well below the critical threshold of 5, and significantly below the median value referred to a control group of non-athletes (5). Bender et al. (2018), focusing on winter sport athletes other than alpine skiers, found a mean PSQI index of 5, signaling a relatively poor quality of sleep. This could be due to the extreme physical and mental efforts required in alpine skiing. Indeed, only athletes that manage to have a good quality of sleep tend to continue practicing this sport, while in the control group, there was lower pressure towards a very high sleep quality/quantity. The overall good sleep quality was also confirmed considering the modest levels of self-assessed degree of anxiety and waking up in the night before a competition. Furthermore, the athletes attributed a high score (3.26/4) to the importance of sleep on performance, thereby showing that they fully understand how crucial sleep is for their performance.

This hypothesis is further confirmed when analyzing sleep quality in alpine skiers compared to athletes of other sport activities. Mean sleeping time during the competition was 7 h 57 min for alpine skiers, a much higher time compared to previous data in the literature. For example, the previous research by Leeder et al. (2012) showed a mean sleeping time of 6 h and 54 min in 47 Olympic athletes. In Swinbourne et al. (2016) on 175 elite and highly trained rugby and cricket athletes, 50% of athletes were found to be poor sleepers. For comparison to our sample, the percentage of alpine skiers that had a PSQI index greater or equal 5 was only 26.19%. Hrozanova et al. (2018) found an average sleeping time of 7 h and 21 min in elite cross-country skiers and biathlon athletes.

Compared to the control group, alpine skiers had better indexes for sleep duration, sleep latency, and sleep quality. These results could be explained by the strict sleep hygiene adopted by alpine skiers compared to non-athletes, and/or by the physiological effects of physical exercise on sleep. Many studies have highlighted a positive effect of physical exercise on sleep quality (e.g., Hurdiel et al. 2017; Kashefi et al. 2014; Nguyen and Kruse 2012), although most of the studies on these topics have considered a moderate level of exercise. Indeed, the systematic review of Wang and Boros (2021) has shown mixed results with some studies that reported no association between intense physical activity and sleep quality/quantity (e.g., Myllymäki et al. 2011; Pengpid and Peltzer 2018), while other studies highlighted a significant relationship between intense physical activity and sleep quality (Lang et al. 2013; Morita et al. 2017). Considering that previous literature has often shown poor sleep quality in athletes (Bender et al. 2018; Drew et al. 2018; Gupta et al. 2017; Hoshikawa et al. 2018; Lucidi et al. 2007; Mah et al. 2018; Samuels 2008; Turner et al. 2021), it seems that the better sleep quality that we found in alpine skiers is not due to physical exercise but to their acknowledgement of the crucial importance of sleep for their performance and therefore to their strict sleep hygiene. Similarly, in Tuomilehto et al. (2017), 75% of athletes considered that counselling on sleep hygiene would improve their performance. Indeed, in the same study counselling and individual treatment were found to significantly improve the quality of sleep with a mean alteration of 0.6 in a scale from 0 to 10.

The study has limitations due to the fact that sleep quality, quantity, and chronotype were assessed only once with a self-report questionnaire (PSQI and MEQ). Future research in which chronotype and sleep parameters in alpine skiers are assessed by actigraphy or polysomnography, possibly multiple times, is needed to better validate and consolidate the results of this study. The sample of alpine skiers included athletes of different levels, ranging from non-professional athletes competing in FISI provincial competitions to professional athletes competing in FIS Alpine Ski World Cup. In this study, we considered five categories of alpine skiers (world, European, national, regional provincial); however, there was a limited number of athletes in the top categories thus reducing the possibility to draw conclusions about the role of competitive level on the variables examined in this study.

The results of this study, a marked shift towards morningness chronotype distribution and an overall good sleep quality in alpine skiers compared to non-athletes, could be applied in sport psychology for orienting young athletes' choice of sport that would match their chronotype.

In addition, it would be important for coaches to include chronobiology and sleep management education

that would allow athletes to optimize their performance. Due to the high prevalence of morning types in alpine skiers, it would be advisable to plan trainings and competitions during the morning and early afternoon. From a more scientific perspective, future studies should better investigate the causality of the relationship between physical and mental demands in sport and the increased skew of chronotype distribution toward morningness.

Disclosure statement

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Data availability statement

The data that support the findings of this study are openly available in "figshare" at http://doi.org/10.6084/m9.figshare. 22639294.

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