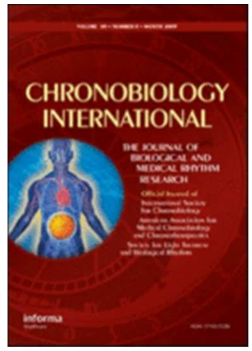

Chronotype, sport participation, and positive personality-trait-like individual differences

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Abstract

Chronotype and sport participation have been found to relate to positive personality-trait-like individual differences (PTLID). To date, research has focused exclusively on the morningness-eveningness dimension of chronotype, and little is known about the relationship between chronotype and various characteristics of sport participation (e.g., training time). This investigation had three primary objectives: 1) to extend the current evidence base by exploring how sport participation and PTLID relate to chronotype amplitude, 2) to explore how chronotype (morningness-eveningness and amplitude) relates to various characteristics of sport training and competition, and 3) to explore the independent and interrelated contribution of sport participation and chronotype to PTLID. The sample included 976 non-athletes (493 women, 483 men) and 974 athletes (478 women, 496 men). Participants completed a battery of questionnaires targeting sport participation characteristics, six positive PTLID (hope, optimism, perseverance, resilience, self-efficacy, and trait emotional intelligence) and chronotype dimensions. Results showed that morningness-eveningness was negatively related to positive PTLID but was unrelated to sport participation. Greater diurnal fluctuations (amplitude dimension) were associated with lower positive PTLID values, lower sport participation, and shorter training durations. Positive PTLID were also associated with better sleep quality and a shorter sleep duration. Chronotype (morningness-eveningness and amplitude) and sport participation had independent associations with PTLID. These findings suggest that changes in sport participation and activity times might be a useful approach to developing positive PTLID.

Keywords: physical activity, sport, exercise, morningness-eveningness, distinctiveness, sleep quality, sleep quantity, personality, positive psychology

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INTRODUCTION

Effective individual functioning is a core element of positive mental health (Bolier et al., 2013). Developments in positive psychology theory and research show that positive individual functioning is connected to high scores on desirable traits such as optimism, resilience, and emotional control (Seligman & Csikszentmihalyi, 2000). These positive individual traits are often labeled positive personality-trait-like individual differences (PTLID; Laborde et al., 2013). PTLID's have been found to relate to chronotype (Adan et al., 2012; Randler, 2008) and sport participation (e.g., Allen & Laborde, 2014; Guillén & Laborde, 2014). Chronotype – individual differences in circadian rhythms – is often conceptualized as a unidimensional construct (for exception, see Caci et al., 2005; Caci, Deschaux, Adan, & Natale, 2009) comprising a single "morningness-eveningness" dimension (the preferred time of day for various activities). More recently, in addition to morningness-eveningness, researchers have begun to explore chronotype amplitude – the magnitude of fluctuations in biological rhythms (Dosseville et al., 2013). Chronotype amplitude is an important component of circadian rhythms in health and occupational contexts, predicting outcomes such as tolerance to unpleasant conditions (e.g., shift work or jetlag; Adan et al., 2012; Saksvik et al., 2011). In this investigation, we explore components of chronotype (morningness-eveningness and amplitude) as they relate to sport participation and positive PTLID.

Chronotype and positive PTLID

Chronotype has been found to have an important connection to positive PTLID. A tendency towards morningness is positively associated with introversion, conscientiousness, agreeableness and persistence (Adan et al., 2012), emotional control and emotional stability (Adan et al., 2012; Cavallera et al., 2014), adaptive emotional functioning (Adan et al., 2012), and an adaptive temperament profile (Jankowski, 2012). On the other hand, people that have a tendency towards eveningness appear more extraverted, impulsive, novelty seeking and open-minded (Adan et al., 2012), and also report higher levels of secondary psychopathy and exploitive narcissism (Jonason et al., 2013). Taken together, it appears that positive individual functioning (as defined by Seligman & Csikszentmihalyi, 2000) is associated with a tendency towards morningness. One of the reasons offered for this finding is "social jet lag" – evening people function less well in modern environments due to discrepancies between internal and social time – societies generally promote morning-oriented functioning (Jankowski, 2014).

The research to date on chronotype and PTLID has most often targeted the dimensions of the big five personality traits (extraversion, openness, agreeableness, neuroticism, and conscientiousness) and the four dimensions of temperament (novelty seeking, harm avoidance, reward dependence, and persistence) (Adan et al., 2012); and PTLID constructs are often conceptualized as independent rather than forming a composite variable. In the current investigation we conceptualise PTLID components as formative and explore correlates of the PTLID latent construct. In addition, the research to date has focused exclusively on the morningness-eveningness dimension and has not explored the potential contribution of chronotype amplitude. It has been proposed that greater diurnal fluctuations might disrupt individual functioning and in particular have a negative effect on the way people adapt to their social environment (Folkard et al., 1979). Thus, it is conceivable that high scores on chronotype amplitude (greater fluctuations in diurnal biological rhythms) relate negatively to positive PTLID.

There is no general consensus regarding the positive PTLID components that most accurately capture positive individual functioning. In this investigation we target six PTLID variables that have been found to have an important role in sport and physical activity (Guillén & Laborde, 2014) – namely, self-efficacy, hope, optimism, perseverance, resilience, and emotional intelligence. These PTLID components have been found to relate to the chronotype "morningness-eveningness" dimension. In particular, general self-efficacy – the belief that one's actions are responsible for successful outcomes (Schwarzer & Jerusalem, 1995) – appears to be greater in morning type people (Roeser et al., 2012), and dispositional pessimism – a generalized expectation that bad things will happen (Scheier et al., 1994) – appears to be greater in evening type people (Hidalgo et al., 2009).

Previous research has also explored perseverance and trait emotional intelligence. Perseverance refers to the propensity of being eager to work hard in spite of fatigue or frustration (Cloninger et al., 1994) and has been consistently found to be higher in morning-type people (Adan et al., 2010; Antúnez et al., 2014; Randler & Saliger, 2011). Moreover, perseverance has been advanced as one reason for the higher academic performance of morning people, despite the negative association between cognitive ability and morningness (Preckel et al., 2011; Preckel et al., 2013). Trait emotional intelligence represents a constellation of emotional self-perceptions situated at the lower levels of personality (Petrides et al., 2007) and has also been found to be higher in morning-type people (Antunez et al., 2013). However, the scale used to measure emotional intelligence to date – the trait meta-mood scale – has received some criticism in terms of its ecological validity (Petrides, 2009a). We address this in the current investigation through our use of a new validated measure – the trait emotional intelligence questionnaire (Petrides, 2009b).

Two components of PTLID that have not explicitly been explored in relation to chronotype are *hope* – an expectation of success relative to goals (Snyder et al., 1991) – and *resilience* – a positive adaptation towards risk and the ability to maintain stable levels of physical and mental function (Wagnild & Young, 1993). However, morning people have been found to show more adaptive responses to stressful events (Ottoni et al., 2012) and hope is considered a key ingredient of positive individual functioning (Seligman & Csikszentmihalyi, 2000). Thus, we might expect a tendency towards morningness to be associated with greater levels of hope and resilience. In short, for each of the positive PTLID components included we can hypothesize a positive association with a tendency towards morningness.

Sport participation and positive PTLID

Sport participation is associated with higher reported positive PTLID (Allen & Laborde, 2014; Guillén & Laborde, 2014). Four of the PTLID components we investigate here – hope, resilience, perseverance and optimism – were included in a recent study of the correlates of sport participation (Guillén & Laborde, 2014). In the investigation, these four components were amalgamated under an umbrella term – *mental toughness* – and were found to be higher among sport participants than non-participants, and in the athlete sample those that scored highly on these traits tended to spend a greater amount of time in practice sessions (Guillén & Laborde, 2014). The two remaining PTLID components that we explore here – self-efficacy and emotional intelligence – have also been investigated in relation to sport and physical activity. For example, a systematic review of physical activity intervention programs in youth found that increasing sport participation was positively related to the development of self-efficacy (Cataldo et al., 2013). Other (cross-sectional) research has found that physical activity and sport participation relate to higher levels of trait emotional intelligence (e.g., Li et al., 2009; Saklofske et al., 2007a, 2007b). In short, current investigations point toward a positive association between participation in sport and positive PTLID.

Chronotype and sport participation

Emerging research has found that chronotype is related to participation in sport and physical activity (Antunez et al., 2013; Shechter & St-Onge, 2014; Urban et al., 2011). In one investigation of 22 healthy adults, a later bedtime, waking time, and midpoint of sleep were associated with less time involved in moderate-to-vigorous physical activity and more time in sedentary behavior (Shechter & St-Onge, 2014). Another study of 2565 Hungarian high-school students found that morningness was associated with lower levels of physical inactivity compared to eveningness (Urban et al., 2011). And in a sample of 1011 adults, morning-type people were involved in more physical activity than evening-type people (Antunez et al., 2013). This emerging research indicates that morning-type people tend to have higher rates of physical activity and lower rates of sedentary behavior. However, little is known about the association of chronotype and sport participation. Some research has explored chronotype and moment of the day in sport performers (Kunorozva et al., 2014; Kunorozva et al., 2012; Rae, Stephenson, & Roden, 2015) and found that athletes perceive the same level of physical exertion as being less effortful (Kunorozva et al., 2014) and record faster performance times (Rae et al., 2015) when the time of day matches their circadian preference. This indicates that the time of day a competition is organized is likely to favor the athletes with a matching morningness-eveningness preference (Kunorozva et al., 2012). Regarding the amplitude dimension of chronotype, we are unaware of any previous research investigating its association to sport participation characteristics.

The current investigation

The current investigation seeks to extend the current evidence base in several ways. First, we explore chronotype amplitude (in addition to morningness-eveningness) and its association to sport participation characteristics and positive PTLID. To date, much of the research on chronotype has focused exclusively on morningness-eveningness and negated the potential importance of the amplitude diurnal variability in biological rhythms. Second, we extend the research exploring chronotype and sport participation by exploring associations between the two dimensions of chronotype and specific characteristics of sport participation – namely, how often people participate, how long the training session last, and at what time of day people train and compete. Third, the interrelationships observed in past research – significant associations between sport participation, chronotype and PTLID – mean that associations are potentially independent or shared. We explore whether sport participation and chronotype have independent or interrelated associations with PTLID. For example, a tendency towards morningness might relate to greater participation in organized sport, and this participation in sport might account for the positive associations observed between chronotype and PTLID, given that sport participation is associated with positive PTLID. We explore this possibility by concurrently assessing sport participation, chronotype and PTLID.

In light of the evidence reviewed, we formulated a series of directional hypotheses. First, we hypothesized a positive association between sport participation and positive PTLID, a negative association between morningness-eveningness and positive PTLID, a negative association between diurnal fluctuations and positive PTLID, a negative association between morningness-eveningness and sport participation, and a negative association between diurnal fluctuations and sport participation. The hypotheses targeting chronotype amplitude were formulated based on predictions that people with low amplitude rhythms show better adjustment (Folkard et al., 1979). In relation to sport participation components, we hypothesised a positive association between morningness-eveningness preference and the time of day athletes' usually train and compete. We also hypothesised that chronotype would be associated with athlete weekly hours of practice and training duration (morningness associated with a higher number of weekly hours of practice and with greater training duration; greater amplitude associated with fewer practice sessions and of a shorter duration).

No specific hypotheses were formulated regarding independent or interrelated associations between sport participation, chronotype, and PTLID.

METHOD

Participants

The sample included 976 non-athletes (mean age = 22.49, age range = 18 – 46; 493 women, 483 men) and 974 athletes (mean age = 21.21, age range = 18 – 35; 478 women, 496 men). For athletes, 386 were participating in individual sports and 563 were participating in team sports. All athletes were involved in organized competitive sports. The average number of sleep hours for non-athletes was 7.6 (*SD* = 1.1) and the number of sleep hours for athletes was of 7.6 (*SD* = 1.0). Sleep quality for non-athletes (mean = 3.8, *SD* = 0.7) was similar to that reported by athletes (mean = 4.0, *SD* = 0.7). Approximately half of the athlete sample (*n* = 498) and half of the non-athlete sample (*n* = 493) reported that they routinely take naps. Athletes practiced their sport on average 7.9 (*SD* = 3.9) hours each week with a mean training duration of 109 minutes (*SD* = 35 minutes). The athletes trained in the morning (*n* = 59), afternoon (*n* = 640) and evening (*n* = 275), and competed most often in the morning (*n* = 423), afternoon (*n* = 392) and evening (*n* = 158). This research complied with the tenets of the Declaration of Helsinki and the international ethical standards of chronobiological research (Portaluppi et al., 2010).

Questionnaires

Demographic questions. The 1,950 participants completed a single item measure of their regular participation in organized sport. Participants that answered with "yes" were classified as athletes, and those that answered "no" were classified as non-athletes. Regarding sleep habits, participants were asked about sleep quantity (the average number of hours sleep per night), sleep quality (measured on a scale from 1 "very bad" to 5 "very good"), and if they routinely nap during the day (with binary responses of "yes" or "no"). The athlete subsample completed additional questions about their expertise level (scored from 1 "lowest expertise level" [such as district level] to 5 "highest expertise level" [such as international athlete]), the type of sport they compete in (individual sport or team sport), how many hours they practice each week, the average duration of training sessions, the time of day they generally train (1-morning; 2-afternoon; 3-evening) and the time of day they generally compete (1-morning; 2-afternoon; 3-evening).

Chronotype. To assess chronotype, we used the Caen Chronotype Questionnaire (Dosseville et al., 2013). This 16-item questionnaire includes two dimensions: a morningness-eveningness dimension (e.g., "my work goes better in the afternoon than before noon") and an amplitude dimension (e.g., "there are moments in the day where I would prefer to avoid any work"). High scores on the morningness-eveningness dimension are indicative of a preference to perform activities in the evening (rather than the morning), and high scores on the amplitude dimension are indicative of perceptions of greater diurnal fluctuations. Reliability coefficients (Cronbach's alpha) were .78 (morningness-eveningness) and .75 (amplitude).

Self-efficacy. The general self-efficacy scale (Schwarzer & Jerusalem, 1995) consists of 10 items. Sample item: "I can always manage to solve difficult problems if I try hard enough". Participants indicate the extent to which they agree or disagree with each of the items from 1 (*not at all true*) to 8 (*exactly true*). Higher scores reflect greater levels of general self-efficacy. In our study, Cronbach's alpha for the entire scale was .83.

Hope. The Snyder's Hope Scale (Snyder et al., 1991) uses 12 items ("I can think of many ways to get out of a jam") to assess trait levels of hope. Participants indicate the extent to which they agree with each item scoring from 1 (*strongly disagree*) to 8 (*strongly agree*).

Higher scores reflect greater levels of dispositional hope. In our study, Cronbach's alpha for the full scale was .86.

Optimism. The Life Orientation Test-Revised (Scheier et al., 1994) was used to assess dispositional optimism. The scale consists of six items (e.g., "in uncertain times, I usually expect the best) and an additional four filler items. Respondents indicate the extent to which they agree with each item on a 5-point scale (4 = "*strongly agree*", 3 = "*agree*", 2 = "*neutral*", 1 = "*disagree*", and 0 = "*strongly disagree*"). Higher scores reflect greater levels of dispositional optimism. Cronbach's alpha in our study sample was .81.

Perseverance. Perseverance (often named "persistence") was assessed using the persistence dimension of the Temperament and Character Inventory-Revised (Cloninger et al., 1994). This subscale includes 35 items (e.g., "I am often so determined that I continue working long after other people have given up") and consists of four dimensions. The four dimensions can be averaged to create a composite perseverance score. The 35 items are scored on a scale from 1 (*strongly disagree*) to 5 (*strongly agree*). Higher scores reflect greater levels of perseverance. In this investigation we use the composite score only ($\alpha = .84$).

Resilience. The short form Resilience Scale (Wagnild & Young, 1993) was used to assess trait resilience levels. This assessment measure contains 15 items (e.g., "I do not dwell on things that I can't do anything about") that are scored on a seven point scale from 1 (*disagree*) to 7 (*agree*). Higher scores reflect greater levels of resilience. Cronbach's alpha for our study sample was .91.

Emotional intelligence. To assess trait emotional intelligence, we used the short version of the trait emotional intelligence questionnaire (Petrides, 2009b). This questionnaire includes 30 items (e.g., "expressing my emotions with words is not a problem for me") that are scored from 1 (*completely disagree*) to 7 (*completely agree*). Higher scores reflect greater levels of emotional intelligence. In our study, Cronbach's alpha was .82.

Procedure

Participants were given a brief overview of the general aims of the study (informed consent) and given the opportunity to withdraw from participation. Written informed consent was obtained from all participants prior to their participation. Participants were asked to complete the battery of psychological assessments in a single 40 minutes session. They did not receive any compensation for participation. The study received university-level ethical approval from the lead authors' university ethics committee.

Data analysis

Initial data screening indicated that all assumptions for performing statistical tests were met (e.g., normality, linearity). To explore associations between chronotype and sport participation characteristics it was important to separate the sample into "athletes" and "non-athletes". Linear (stepwise) regression analyses were used to explore the contribution of sport participation components to chronotype in the athlete sample. Chronotype dimensions (morningness-eveningness and amplitude) were set as dependent variables and independent variables were entered in sequential steps. At Step 1 we controlled for demographic confounding variables by entering age, gender, the other chronotype dimension (i.e., amplitude when morningness-eveningness was taken as a dependent variable, and vice-versa), sleep quantity and sleep quality. At Step 2, we entered variables related to sport participation in a stepwise fashion (bidirectional elimination procedure): expertise level, type of sport, number of weekly sessions, training duration, training schedule, and competition schedule. Beta coefficients (and their standard error) were used to identify salient predictors.

To explore the interrelationships between chronotype, sport participation and positive PTLID, we adopted a structural equation modeling approach that would enable positive

PTLID to be modeled as a single latent variable. The structural equation modeling was performed using AMOS 22.0. A general (a priori) model with direct paths connecting chronotype dimensions to positive PTLID and indirect paths from chronotype dimensions to positive PTLID through sport participation was assumed. In the model we controlled for sleep quantity and sleep quality given their connection to positive PTLID (Liu et al., 2013; Mauss et al., 2013). We used a series of cut-off criteria to assess model fit (Hu & Bentler, 1999) and using standardised factor loadings and error variances made adjustments to develop the best fitting model connecting study variables. The following fit indices (and cut-off values) were used: the standardized root mean square residual (SRMR, 0.08), the root mean square error of approximation (RMSEA, 0.06), the non-normed fit index (NNFI) which is called the Tucker Lewis Index TLI (0.95) in AMOS (Arbuckle, 2008, p. 597), and the comparative fit index (CFI, 0.95). In addition we provide the χ^2 value as an auxiliary assessment of model fit, with a lower χ^2 value indicative of a better fit (Jöreskog, 1993).

RESULTS

Linear regression: chronotype and sport participation

Means, standard deviations and sub-sample correlations are presented in Table 1. Findings from the linear regression models are reported in Table 2. For each model, there was no evidence of multicollinearity (VIF's < 2.00) and no obvious multivariate outliers (Cook's distance). For morningness-eveningness, control variables were related to chronotype at Step 1 ($R^2 = .04$, $p < .01$). Two factors were found to contribute meaningfully to this multivariate effect (amplitude, $\beta = .18$; sleep quantity, $\beta = .07$). Over the variance accounted for by control variables, there was a significant effect shown for sport participation components ($\Delta R^2 = .02$, $p < .01$) primarily through the contribution of competition schedule ($\beta = .14$, $p < .01$). The positive regression coefficient indicates that athletes with a preference for eveningness tended to participate in sport competitions that took place later in the day ($R^2_{\text{Final model}}$ = .06). For amplitude, control variables were again related to chronotype at Step 1 (R^2 = .05, p < .01). Four factors were found to contribute to this multivariate effect (age, β = –.11; gender, β = .07; morningness-eveningness, β = .18; sleep quality, β = –.11). Over the variance accounted for by control variables, there was a significant effect shown for sport participation components (ΔR^2 = .02, p < .01) primarily through the contribution of training duration (β = –.14, p < .01). The negative regression coefficient indicates that athletes reporting greater diurnal fluctuations had shorter training sessions ($R^2_{\text{Final model}}$ = .07).

**** *Insert Table 1 near here* ****

**** *Insert Table 2 near here* ****

Structural equation modeling: chronotype, sport participation and positive PTLID

The Mardia's coefficient value was 3.83 (critical ratio: 4.90). A Mardia's coefficient lower than 5.00 (critical ratio < 8.00) indicates multivariate normality of the data, allowing a maximum-likelihood estimation approach (Bentler, 2005). The first (a priori) model showed an unacceptable fit to the data, χ^2 (42) = 763.13, p < .01, CFI = .90, TLI = .87, RMSEA = .09, SRMR = .06. Observation of modification indexes showed several ways we could improve the model. First, we deleted the link between morningness-eveningness and sport participation. The model continued to show an unacceptable fit to the data (χ^2 (42) = 763.14, p < .01, CFI = .90, TLI = .87, RMSEA = .09, SRMR = .06) and so, based on the next highest modification index (176.12) we added covariance between the errors of emotional intelligence and optimism. This improved the model somewhat (χ^2 (42) = 574.79, p < .01, CFI = .93, TLI = .90, RMSEA = .08, SRMR = .06) but values were still below recommended levels. The next three highest modification indexes indicated that the model could be improved by adding covariance between the errors of the two chronotype dimensions (82.07), covariance between the error variances of sleep quantity and sleep quality (81.64), and covariance between emotional intelligence and resilience (40.22). The final model (depicted in Figure 1) showed an acceptable fit to the data, χ^2 (39) = 357.55, $p < .01$, CFI = .96, TLI = .94, RMSEA = .063, 90% CI [.057, .069], SRMR = .04.

**** *Insert Figure 1 near here* ****

DISCUSSION

This cross-sectional investigation explored the interrelationships between sport participation, chronotype dimensions (morningness-eveningness and amplitude) and positive PTLID. Our findings provide partial support for our hypotheses – a positive association was found between sport participation and PTLID, a negative association between amplitude and sport participation, a negative association between amplitude and PTLID, and a negative association between morningness-eveningness and PTLID. Sport participation characteristics (time of competition and duration of training sessions) were also related to chronotype morningness-eveningness and amplitude, respectively.

The finding that morningness-eveningness was unrelated to sport participation is surprising and seems to contradict findings in previous studies (Antunez et al., 2013; Shechter & St-Onge, 2014; Urban et al., 2011). One possible explanation for the discrepancy might be that our study focused on sport participation rather than whether people were regular or non-regular exercisers. It might be the case that morningness-eveningness is unimportant for participation in organized activities such as sport (a subset of physical activity) but is important for the amount of physical exertion people experience in their day-to-day activities. Alternatively, the inclusion of the amplitude dimension in the current research may have accounted for the variance often explained by chronotype on sport participation, given the positive correlation observed between the two chronotype dimensions (Dosseville et al., 2013). Chronotype amplitude had a negative association with sport participation and PTLID, indicating that people who experience greater diurnal fluctuations tend to participate in less sport and report lower PTLID.

The negative association between amplitude and positive PTLID is supportive of theoretical predictions that stable functioning throughout the day is related to better adjustment (Folkard et al., 1979). Interestingly, an indirect association was also observed between amplitude and positive PTLID through sport participation. A more stable diurnal biological rhythm was associated with greater participation in sport that, in turn, was associated with greater positive PTLID. The positive association between sport participation and PTLID is consistent with findings presented in previous research (Guillén & Laborde, 2014). In line with trait emotional intelligence theory regarding overlap between emotional intelligence and other psychological constructs (see Petrides, 2009b) we added covariance between emotional intelligence and resilience, and between emotional intelligence and optimism. We found that people reporting a preference for morningness also reported greater positive PTLID. This is consistent with a large body of research supporting a connection between morningness and positive individual functioning (Adan et al., 2012). Taken together, the data demonstrate that both chronotype amplitude and morningness-eveningness are important for PTLID and that amplitude might have an important connection to PTLID, both directly and through its association with sport participation.

To control for the potential confounding role of sleep quality and sleep quantity, we included these variables in the structural equation model. These variables often correlate highly (e.g., Lemola et al., 2013) and it is interesting to note that the two sleep variables had different associations with PTLID. Sleep quantity was negatively associated and sleep quality was positively associated meaning that people who sleep well, and those who sleep for a shorter duration, also tend to report more positive PTLID. Previous studies of sleep quality and quantity have observed some interesting associations. For sleep duration, the connection to positive psychological constructs such as optimism and self-esteem might not be linear but rather reversed J-shape or U-inverted (Lemola, Räikkönen, Gomez, & Allemand, 2013; Lemola et al., 2011). To explain, individuals sleeping 7-8 h were found to have higher scores on optimism and self-esteem than individuals with short sleep duration (< 6 h) or long sleep duration (> 9 h) (Lemola et al., 2013) suggesting that too little *and* too much sleep might be associated with negative individual functioning. Moreover, the fact that shorter sleep was associated with higher PTLID might be explained by the finding that sleep latency in the following night is decreased given sleepiness, triggering then a higher sleep quality. This would be in line with some therapeutic approaches to depression that use sleep deprivation to induce sleepiness and increase sleep quality on the following night, and this is associated with lower depressive symptoms (Giedke & Schwarzler, 2002; Hemmeter, Hemmeter-Spernal, & Krieg, 2010). In our sample, a greater sleep duration was related to a preference for eveningness that, in turn, was related to lower positive PTLID. The finding that sleep quality was positively associated with PTLID is consistent with previous research connecting sleep quality to positive individual functioning and subjective well-being (e.g., Mauss et al., 2013). In addition, our findings are in line with previous work where sleep quality was found to be positively associated to positive psychological characteristics such as optimism and self-esteem (Lemola et al., 2011). In the study of Lemola et al., sleep quality was assessed based on sleep latency, and sleep efficiency was defined as the actual sleep time divided by the time in bed, thus including sleep latency, illustrating the association between shorter sleep latency and positive psychological characteristics. These findings suggest that researchers might consider the inclusion of positive PTLID in their definition of optimal sleep (Blunden & Galland, 2014) and might consider targeting sleep-related variables for the development of positive PTLID. The implications of such research might include changing (limiting) the use of technologies (e.g., screen time) in the evening that could disturb sleep quality and hence provoke negative health-related physical and psychological consequences (Arora et al., 2013, 2014).

In addition to overall sport participation, we also explored associations between chronotype and various characteristics of sport participation. The most salient factor associated with morningness-eveningness was competition schedule. Athletes that reported a preference for eveningness were also found to take part in sport activities that occur later in the day. We are unable to determine the direction of this relationship from our study design, but it is possible that these factors are related in a bidirectional manner – a preference for eveningness leading to people choosing to take part in activities that occur in the evening and being involved in evening competitions leading to a preference for eveningness (Kunorozva et al., 2012). The most salient factor associated with amplitude was training duration. Athletes that reported a more stable biological rhythm also reported longer duration training sessions in their sport. Again we might consider the potential bidirectional connection this association might reflect – longer training sessions might have physiological benefits that contribute to a more stable diurnal biological rhythm, and a more variable diurnal biological rhythm might have physiological consequences (e.g., fatigue) that lead to athletes shortening their training sessions (Routledge et al., 2010). Intervention type studies are warranted to address these possibilities directly.

The findings of this study need to be considered in reflection of the methodological design. The cross-sectional nature of the research means that causality cannot be determined and it is possible that many of the associations found occur in a different direction to that presented. Moreover, structural equation modeling can produce many equally plausible and statistically equivalent models. The structural equation model we present reflects the likely causal connections between measured variables as suggested through previous research and theoretical developments. Second, the use of self-report assessments means that the data is open to response bias (e.g., social desirability effects) and future research might benefit from integrating more objective measurements, particularly those of chronotype amplitude (for example, skin temperature) and physical activity (e.g., pedometers). Third, we assessed sleep duration and sleep quality on a likert-type scale and did not differentiate between week days and week-end days. Future studies might look to use go-to-bed and get-up time as an alternative measure of sleep duration and include separate measures for working and non-working days.

In spite of the limitations outlined above, the findings of this investigation might be of value to those working in applied settings. To develop positive PTLID researchers might consider developing interventions that target chronotype amplitude and morningness-eveningness. In particular, simple intervention techniques such as regulating sleep-wake time patterns and meal times might be a useful method of developing a tendency towards morningness and less variable biological rhythms (Adan et al., 2012). Although there is no guarantee that changing chronotype components will cause changes in PTLID – as our study did not address causality – developments in theory and research (e.g., Folkard et al., 1979) suggest this might be the case. Further, researchers interested in developing sport participation (or longer training sessions) might also consider interventions targeting chronotype amplitude. The identification of simple practical interventions that can help regulate biological rhythms is therefore a critical direction for further research and the advancement of evidence-based practice in chronobiology. Such interventions will need to take into account the constraints of modern society and social jetlag (Jankowski, 2014). At this point it seems important to note that human prosperity requires people not fitting entirely the social norm in order to progress towards novel and creative directions. Indeed, research has found that a tendency towards eveningness is associated with extraversion, impulsivity, novelty seeking and open-mindedness (Adan et al., 2012). Thus, from a societal point of view a balance of "larks and owls" would seem to provide the greatest benefits for the collective. Consultants need to take into account the individual needs of their clients before targeting changes in chronotype.

CONCLUSION

This investigation explored the interrelationships between chronotype, sport participation, and positive PTLID. We found that sport participation was positively related to PTLID and negatively related to chronotype amplitude, and that chronotype amplitude and morningness-eveningness were negatively related to PTLID. Sport participation characteristics (time of competition and duration of training sessions) were also related to chronotype amplitude and morningness-eveningness. This investigation highlights the value of the amplitude dimension in chronotype research (Dosseville et al., 2013). Most notable was that sport participation was related to amplitude but not morningness-eveningness. We recommend continued use of the amplitude dimension in chronotype research, and in particular encourage experimental research designs that target the identification of practical interventions that can facilitate a tendency towards morningness and less variable biological rhythms.

DECLARATION OF INTEREST

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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Table 1. *Means, standard deviations and correlations for measured variables*

	Mean	*SD*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Morningness-eveningness	23.82	4.52	-	.23**	–.04	–.01	–.19**	–.08**	–.15**	–.19**	–.04	–.12**	-	-	-	-
2. Amplitude	24.09	4.90	.18**	-	–.11**	–.03	–.27**	–.16**	–.23**	–.32**	–.23**	–.15**	-	-	-	-
3. Sleep quality	3.91	0.70	–.01	–.10**	-	.25**	.18**	.17**	.16**	.06*	.16**	.16**	-	-	-	-
4. Sleep duration	7.62	1.08	.07*	–.01	.16**	-	–.09**	–.05	–.05	–.03	–.09**	–.08**	-	-	-	-
5. Emotional intelligence	4.70	0.70	–.16**	–.19**	.21**	–.04	-	.60**	.69**	.42**	.48**	.62**	-	-	-	-
6. Optimism	3.48	0.65	–.16**	–.15**	.20**	.01	.65**	-	.57**	.32**	.40**	.54**	-	-	-	-
7. Resilience	5.38	0.84	–.11**	–.15**	.19**	–.04	.67**	.55**	-	.53**	.59**	.72**	-	-	-	-
8. Perseverance	3.33	0.47	–.11**	–.27**	.14**	–.01	.51**	.42**	.61**	-	.53**	.54**	-	-	-	-
9. Self-efficacy	3.07	0.46	–.07*	–.18**	.16**	–.06*	.53**	.41**	.65**	.60**	-	.65**	-	-	-	-
10. Hope	5.98	1.12	–.09**	–.15**	.20**	–.07*	.62**	.52**	.73**	.63**	.71**	-	-	-	-	-
11. Weekly practice	7.88	3.90	–.06	–.10**	.10**	–.01	.19**	.14**	.18**	.22**	.16**	.18**	-	-	-	-
12. Training duration	108.54	35.26	–.02	–.15**	.10**	–.06	.16**	.13**	.21**	.22**	.18**	.20**	.65**	-	-	-
13. Competition time	2.38	1.11	.15**	.04	–.05	.05	–.04	–.04	–.06	–.03	–.06	–.07*	–.17**	–.16**	-	-
14. Training time	3.18	0.67	.03	.08*	–.14**	–.02	–.06	–.03	–.10**	.01	–.04	–.07*	–.12**	–.13**	.28**	-
15. Expertise level	2.20	1.13	.05	–.10**	.12**	.09**	.11**	.08*	.17**	.18**	.13**	.13**	.43**	.45**	–.04	.01

*$p < .05$, **$p < .01$

Note. Correlations reported below the diagonal are for athletes (n = 974) and those above the diagonal are for non-athletes (n = 976)

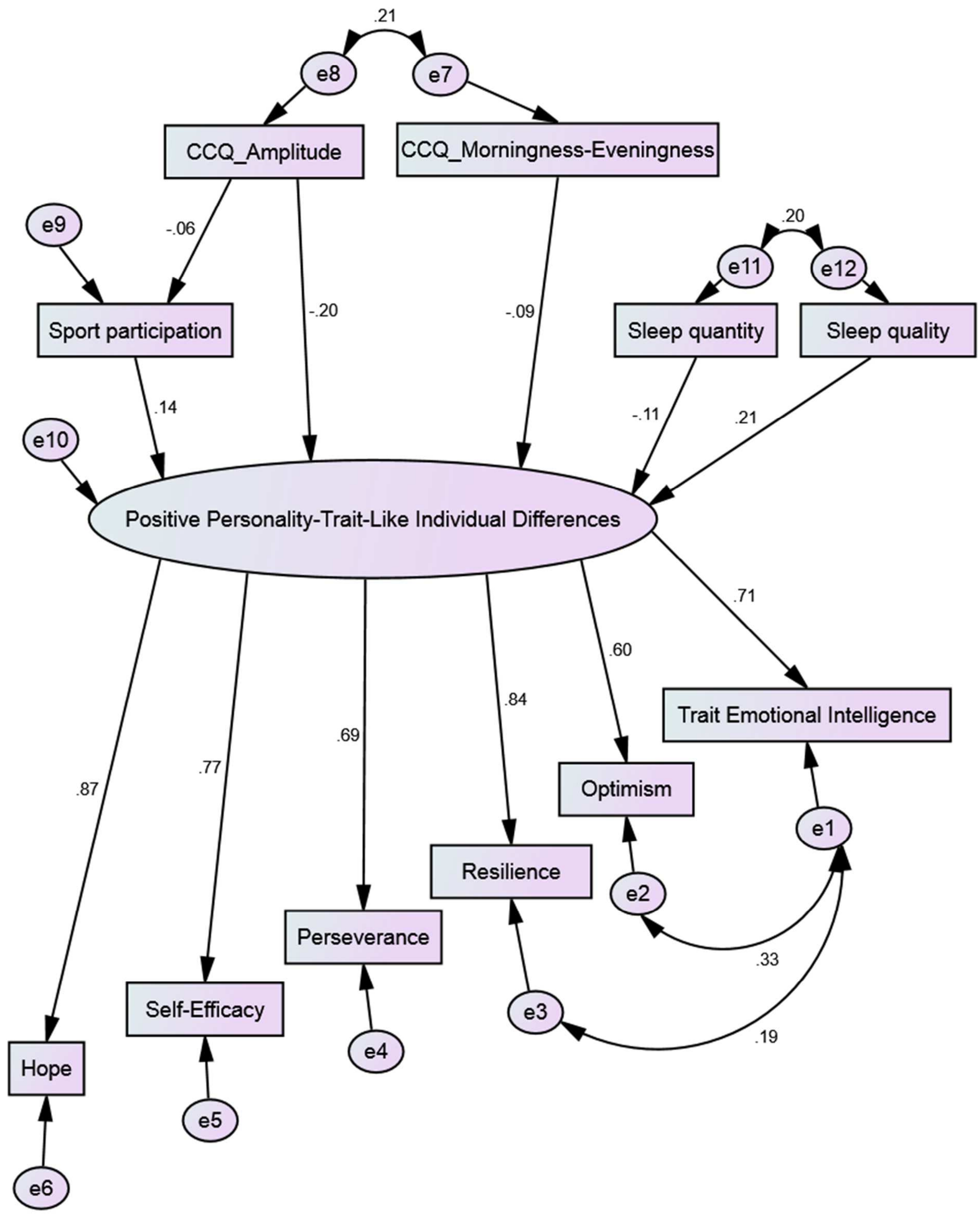
Table 2: *Regression analyses for sport participation characteristics on chronotype in the athlete sample (n = 974).*

	Morningness-eveningness			Amplitude		
	b (s.e.)	*β*	ΔR^2	*b* (s.e.)	*β*	ΔR^2
Step 1 (method: Enter)			0.04**			0.05**
Age	–0.07 (0.42)	–.05		–0.16 (0.05)	–.11**	
Gender	–0.11 (0.28)	–.01		0.67 (0.31)	.07*	
Chronotype dimension	0.16 (0.03)	.18**		0.20 (0.20)	.18**	
Sleep quality	0.02 (0.22)	.01		–0.81 (0.24)	–.11**	
Sleep quantity	0.28 (0.13)	.07*		–0.02 (0.14)	–.01	
Step 2 (method: Stepwise)			0.02**			0.02**
Expertise level	-	-		-	-	
Type of sport	-	-		-	-	
Number of weekly training sessions	-	-		-	-	
Training session average duration	-	-		–0.02 (0.01)	–.14**	
Training schedule (time of day)	-	-		-	-	
Competition schedule (time of day)	0.56 (0.13)	.14**		-	-	

**p* < .05, ***p* < .01

Note: Gender was classified as 1 (female) or 2 (male), type of sport was classified as 1 (individual sport) or 2 (team sport). Chronotype dimension indicates that when morningness-eveningness was taken as a dependent variable for the linear regression, amplitude was entered at Step 1, and vice-versa.

Figure 1. Final model reporting significant associations between chronotype, sport participation and PTLID.



Note. CCQ = Caen Chronotype Questionnaire. Standardized beta's reported. All paths displayed are significant ($p < .05$)