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Cross-sectional and longitudinal associations between psychosocial well-being and sleep in European children and adolescents

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Abstract

Research on associations of positive mental health, in contrast to mental ill-health, with sleep duration and sleep disturbances in young populations is scarce. In particular, longitudinal studies focussing on the influence of positive mental health on sleep characteristics are lacking. Therefore, we investigated cross-sectional and longitudinal associations of psychosocial well-being with sleep duration and sleep disturbances. For the cross-sectional analysis, we used data of 3-15-year-old children and adolescents participating in the 2013/14 examination of the European IDEFICS/I.Family cohort study (*N* = 6,336). The longitudinal analysis was restricted to children who also participated in the 2009/10 examination (*N* = 3,379). Associations between a psychosocial well-being score created from 16 items of the KINDL^R Health-Related Quality of Life Questionnaire covering emotional well-being, self-esteem and social relationships, an age-standardized nocturnal sleep duration *z*-score and two sleep disturbance indicators ("trouble getting up in the morning", "difficulties falling asleep") were estimated using linear and logistic mixed-effects models. Cross-sectionally, a higher well-being score was associated with longer sleep duration and lower odds of sleep disturbances. A positive change in the well-being score over the

4-year period was associated with longer sleep duration and lower odds of sleep disturbances at follow-up. However, there was only weak evidence that higher psychosocial well-being at baseline was associated with better sleep 4 years later. Thus, our results suggest that increases in well-being are associated with improvements in both sleep duration and sleep disturbances, but that well-being measured at one point in time does not predict sleep characteristics several years later.

KEYWORDS
longitudinal studies, multi-country, sleep quality, sleep–wake disorders

1 | INTRODUCTION

Sleep duration of children and adolescents decreased over the last decades (Keyes, Maslowsky, Hamilton, & Schulenberg, 2015; Matricciani, Olds, & Petkov, 2012), and especially adolescents often do not get enough sleep according to their individual need (Hysing, Pallesen, Stormark, Lundervold, & Sivertsen, 2013; Keyes et al., 2015). One factor contributing to insufficient sleep can be an evening circadian phase preference ("eveningness"). This trait occurs more frequently in adolescents in comparison to children, and includes amongst others a preference for late bedtimes and late get up times (Carskadon, Vieira, & Acebo, 1993; Owens, 2014; Randler, Fassl, & Kalb, 2017). Further, difficulties in initiating and maintaining sleep are common in both children and adolescents (Fricke-Oerkermann et al., 2007; Hysing et al., 2013; Spruyt, O'Brien, Cluydts, Verleye, & Ferri, 2005). This is alarming because poor sleep, i.e. short sleep duration and sleep disturbances, and eveningness have previously been shown to be associated with obesity (Cappuccio et al., 2008; Jarrin, McGrath, & Drake, 2013), cardio-metabolic disorders (Quist, Sjödin, Chaput, & Hjorth, 2016), poor academic achievement (Dewald, Meijer, Oort, Kerkhof, & Bögels, 2010) and/or poor mental health (Gregory & Sadeh, 2012; Lovato & Gradisar, 2014; Randler, 2011). With regard to the latter, previous studies typically focussed on mental ill-health, such as depressive symptoms and anxiety (Gregory & Sadeh, 2012; Lovato & Gradisar, 2014). Aspects of positive mental health, the second dimension of mental health next to mental ill-health (World Health Organization, 2005), have less often been investigated in relation to sleep. The concept of positive mental health is closely related to quality of life and subjective well-being (Diener, 1984), and is characterized by positive emotions and resources such as self-esteem, optimism and satisfying personal relationships (World Health Organization, 2005).

Aspects of mental health and sleep are most likely bidirectionally linked through physiological processes. On the one hand, research has shown that stress—which in childhood can emerge from various sources like problems with the family and peers (Ryan-Wenger, Sharrer, & Campbell, 2005)—leads to the activation of the hypothalamic-pituitary-adrenal axis with the release of hormones such as cortisol that affect sleep architecture (Buckley & Schatzberg, 2005). On the other hand, poor sleep has been shown to lead to an additional cortisol release (Buckley & Schatzberg, 2005) and to adversely affect emotional brain networks (Kahn, Sheppes, & Sadeh, 2013). Further, genetic influences on both well-being and sleep have been observed, so there may be shared genetic factors underlying the association (Okbay et al., 2016).

Cross-sectional studies observed good sleep, i.e. amongst others adequate sleep duration and absence of sleep disturbances, and morningness to be associated with higher levels of optimism and self-esteem (Lemola et al., 2011; Randler, 2011), health-related quality of life (HRQoL; Delgado Prieto, Diaz-Morales, Escribano Barreno, Collado Mateo, & Randler, 2012; Hiscock, Canterford, Ukoumunne, & Wake, 2007; Magee, Robinson, & Keane, 2017; Quach, Hiscock, Canterford, & Wake, 2009; Roeser, Eichholz, Schwerdtle, Schlarb, & Kübler, 2012), life satisfaction (Segura-Jiménez, Carbonell-Baeza, Keating, Ruiz, & Castro-Pinero, 2015) and good family relationships (Randler, 2011; Segura-Jiménez et al., 2015). Further, some longitudinal studies reported indicators of good sleep to be predictive of higher self-esteem (Fredriksen, Rhodes, Reddy, & Way, 2004) and HRQoL (Magee et al., 2017; Quach et al., 2009). Although it seems biologically plausible that positive mental health also influences sleep, longitudinal studies focussing on this direction of the association are scarce. Further, only few studies focussed on multiple sleep characteristics such as sleep duration, difficulties falling asleep and sleep efficiency, although they are all interrelated. For example, some researchers have shown longer sleep latency to be associated with shorter sleep duration (Lemola et al., 2011; Nixon et al., 2009). However, intervention studies revealed that sleep latency went down after sleep restriction (Jenni, Achermann, & Carskadon, 2005; Sadeh, Gruber, & Raviv, 2003), possibly as a result of increasing homeostatic sleep drive. This was confirmed by an observational study that has found shorter sleep duration to be associated with shorter sleep latency and better sleep efficiency (Michels, Verbeiren, Ahrens, De Henauw, & Sioen, 2014).

Therefore, the aims of the present study were: (a) to investigate whether psychosocial well-being, as one domain of HRQoL covering emotional well-being, self-esteem, family life and relations to friends, is associated with nocturnal sleep duration and sleep disturbances ("trouble getting up in the morning", "difficulties falling asleep") in 3–15-year-old European children and adolescents; (b) to examine the potential influence of psychosocial well-being on sleep in longitudinal analyses; and (c) to explore whether associations between psychosocial well-being and each single sleep characteristic exist independent of the effect of other sleep characteristics.

2 | MATERIALS AND METHODS

2.1 | Study population

For the IDEFICS study, 2–9-year-old children from Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden were first examined in 2007/08 (*N* = 16,228) and again in 2009/10 after an intervention aiming to prevent childhood overweight (*N* = 11,041 plus 2,555 newcomers; Ahrens et al., 2011). In 2013/14, children participating in IDEFICS (*N* = 7,105) and some newly recruited siblings (*N* = 2,512) were (re-)examined in the framework of the I.Family study (Ahrens et al., 2017).

The cross-sectional analysis for this study was based on 2013/14 data to enable the investigation of associations in both children and adolescents. The analysis comprised only participants aged 3–15 years with complete and plausible information on all variables used in the analysis (*N* = 6,336). The longitudinal analysis included children with complete information in 2009/10 (in the following referred to as baseline) and 2013/14 (in the following referred to as follow-up) because only in these waves all sleep variables of interest were assessed (*N* = 3,379). The selection process of the analysis groups is shown in Figure 1.

2.2 | Procedures

All measures used in the present investigation were obtained by questionnaires. Questionnaires were developed in English, translated into local languages and then back-translated to check for translation errors. Parents answered on behalf of children younger than 12 years old. Before children entered the study, parents provided informed written consent. Additionally, children 12 years and older gave simplified written consent. The Ethics Committees of all study centres gave ethical approval.

2.3 | Sleep duration

Participants reported nocturnal sleep duration and napping time (hours and min) separately for kindergarten/school days, i.e. weekdays, and weekend days/vacations. A weighted average of nocturnal sleep duration was calculated for each child as follows: (nocturnal sleep duration on weekdays*5 + nocturnal sleep duration on weekend days/vacations*2)/7 and transformed to an age-specific *z*-score. Analogously, the weighted average of daily napping time (min) was calculated.

2.4 | Sleep disturbances

We inquired whether the child/adolescent in general has “trouble getting up in the morning” (yes/no) and “difficulties falling asleep” (yes/no). Similar items were used previously in other large population-based studies (Magee et al., 2017).

2.5 | Psychosocial well-being

Psychosocial well-being was measured with 16 items of four subscales of the “KINDL^R Questionnaire for Measuring Health-Related Quality of Life (HRQoL) in Children and Adolescents” (emotional well-being, self-esteem, family life and relations to friends; see Supporting Information, Table S1; Bullinger, Brütt, Erhart, & Ravens-Sieberer, 2008; Ravens-Sieberer & Bullinger, 2000). The KINDL^R Questionnaire was originally developed in German, but was translated to English and other languages. Survey centres were advised to use already existing language versions, if available. At follow-up, response categories corresponded to the original five-point Likert scale (never, seldom, sometimes, often, all the time). At baseline, the two highest response categories were combined into one category. Therefore, we deviated from the original scoring (1–5 points per item) and assigned 0 points for “Never”, and 3 points for both “Often” and “All the time” (at follow-up) or “Often/All the time” (at baseline), respectively (six negatively worded items were coded reversely). Consequently, the score ranged from 0 to 48, with a higher score indicating a higher well-being. In our cross-sectional sample, Cronbach's alpha for this set of items was 0.75. For the longitudinal analysis we created a variable for annual change in well-being to account for the variation of follow-up times between study subjects: Δ well-being score = (follow-up well-being score − baseline well-being score)/(follow-up age − baseline age).

2.6 | Covariates

We considered age in years, sex, highest educational level of parents defined according to the “International Standard Classification of Education (ISCED)” (UNESCO Institute for Statistics, 2012) (levels 0–2 = low, 3–5 = medium and 6–8 = high), pubertal status (yes/no; yes if menarche has occurred in girls or if voice alterations have started or were completed in boys), duration of electronic media use (weighted average of hours of PC and TV consumption on kindergarten/school days and weekend days/vacations), country of recruitment, and an indicator variable for self- versus proxy-reported data.

2.7 | Statistical analysis

2.7.1 | Cross-sectional analysis

Associations between the well-being score and the three outcomes (nocturnal sleep duration *z*-score and the two sleep disturbances) measured at follow-up were investigated using linear and logistic mixed-effects models (Hox, 2010), where a random effect for family affiliation was added to account for the inclusion of siblings in the sample. First, for each outcome a model adjusting for age, sex, country, highest educational level of parents, duration of electronic media

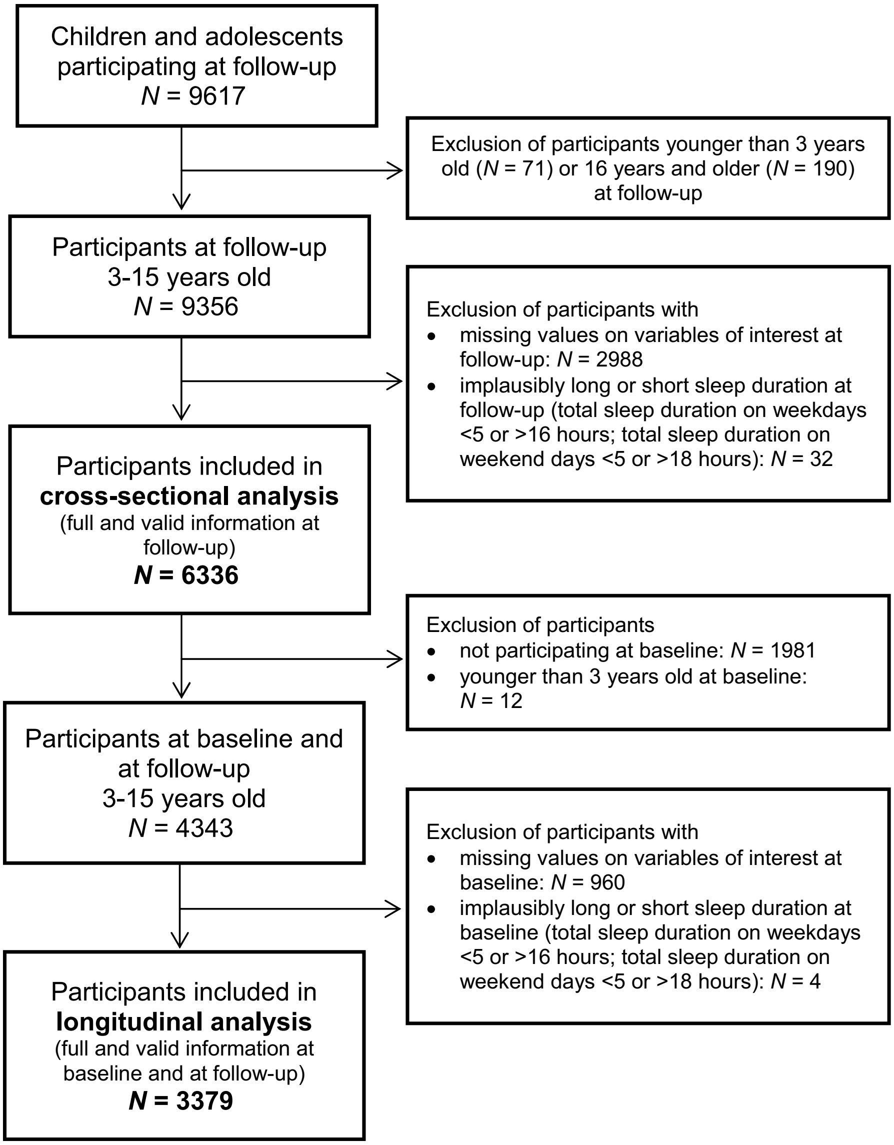

FIGURE 1 Flow chart of children (*N*) included in final analysis groups (cross-sectional and longitudinal analysis), follow-up examination: 2013/14, baseline examination: 2009/10

use, pubertal status, napping time (only in models with nocturnal sleep duration as the outcome), and an indicator for self- versus proxy reports was fitted (Model 1). With Model 2 we explored whether the inclusion of the respective other sleep characteristics in addition to the covariates already included in Model 1 would amend associations (e.g. inclusion of both sleep disturbances in the model investigating the association between well-being and nocturnal sleep duration *z*-score).

Well-being may exert differential effects on nocturnal sleep duration across the sleep duration distribution. For instance, well-being could have a greater effect on sleep duration among those with short sleep duration compared with those with long sleep duration. Thus, we also estimated a quantile regression model (regarding the 0.05, 0.20, 0.35, 0.50, 0.65, 0.80 and 0.95 quantiles) to investigate the potential heterogeneous effect of well-being on different levels of nocturnal sleep duration (same covariates as for Model 1). Quantile regression allows to model any quantile of the outcome distribution and not just the mean as it is done in linear regression (Beyerlein, 2014). In our study, the quantile regression coefficients express how much each specific quantile of the nocturnal sleep duration distribution changes by a 1-unit (≙ 4 points) change in well-being score.

All models were fitted both for the whole analysis group and stratified by age: preschool children (aged 3–5 years); primary school-aged children (aged 6–11 years) and adolescents (aged 12–15 years).

2.7.2 | Longitudinal analysis

Longitudinal associations between well-being and sleep characteristics were again investigated using linear and logistic mixed-effects models including a random effect for family affiliation. We used the following two analytical approaches.

Approach A: Regression of sleep characteristics at follow-up on change in well-being between baseline and follow-up.

Approach B: Regression of sleep characteristics at follow-up on well-being at baseline.

Comparable to the cross-sectional analysis, for both analytical approaches two models with different adjustments were estimated. Model 1 was adjusted for age, sex, country, highest educational level of parents, duration of electronic media use (all at baseline), pubertal status (at follow-up), napping time (at follow-up, only in models with nocturnal sleep duration as the outcome), self- versus proxy-report, and the baseline value of the respective outcome. Model 2 included covariates from Model 1 plus the respective other sleep characteristics. Further, all models following analytical approach A were also adjusted for baseline well-being score, and those following analytical approach B were also adjusted for follow-up time (follow-up age – baseline age).

All models were fitted for the whole analysis group and stratified by age: primary school-aged children (aged 6–11 years at follow-up) and adolescents (aged 12–15 years at follow-up).

2.7.3 | Additional analyses

Instead of using average nocturnal sleep duration, cross-sectional and longitudinal models were fitted separately for weekday and weekend nocturnal sleep duration. Further, in order to assess the reverse direction, well-being at follow-up was regressed on sleep characteristics at baseline.

All analyses were conducted using SAS (Statistical Analysis System; SAS Institute, Cary, USA), Version 9.3. We report 95%

TABLE 1 Description of the study population

	Cross-sectional analysis group (2013/14)				Longitudinal analysis group (2013/14)
	Whole group *N* = 6,336	Preschool children (3–5 years) *N* = 347	Primary school-aged children (6–11 years) *N* = 3,417	Adolescents (12–15 years) *N* = 2,572	Whole group *N* = 3,379
Well-being score, median (interquartile range)	40 (37–43)	43 (40–45)	41 (38–44)	39 (35–42)	40 (37–43)
Nocturnal sleep duration (weekly average, hr), mean (SD)	9.21 (0.94)	9.88 (0.84)	9.50 (0.76)	8.74 (0.98)	9.14 (0.92)
Weekday nocturnal sleep duration (hr), mean (SD)	8.94 (1.06)	9.76 (0.89)	9.32 (0.83)	8.32 (1.05)	8.86 (1.03)
Weekend nocturnal sleep duration (hr), mean (SD)	9.90 (1.26)	10.17 (1.04)	9.94 (1.01)	9.80 (1.54)	9.86 (1.25)
Napping (yes), *n* (%)	1,227 (19.4)	195 (56.2)	339 (9.9)	693 (26.9)	571 (16.9)
Napping time (weekly average, min per day), median (interquartile range)[a]	43 (17–86)	86 (60–111)	39 (17–69)	39 (17–77)	34 (17–64)
Trouble getting up in the morning (yes), *n* (%)	2,407 (38.0)	84 (24.2)	989 (28.9)	1,334 (51.9)	1,332 (39.4)
Difficulties falling asleep (yes), *n* (%)	988 (15.6)	45 (13.0)	388 (11.4)	555 (21.6)	536 (15.9)
Age (years), mean (SD)	10.9 (2.7)	4.6 (0.8)	9.6 (1.5)	13.5 (0.9)	11.5 (1.9)
Girls, *n* (%)	3,236 (51.1)	188 (54.2)	1,692 (49.5)	1,356 (52.7)	1,726 (51.1)
Proxy-report (yes), *n* (%)	3,770 (59.5)	347 (100.0)	3,381 (99.0)	42 (1.6)	1,854 (54.9)
Country, *n* (%)					
Italy	1,085 (17.1)	61 (17.6)	565 (16.5)	459 (17.9)	656 (19.4)
Estonia	1,083 (17.1)	76 (21.9)	568 (16.6)	439 (17.1)	714 (21.1)
Cyprus	1,238 (19.5)	94 (27.1)	563 (16.5)	581 (22.6)	367 (10.9)
Belgium	266 (4.2)	6 (1.7)	200 (5.9)	60 (2.3)	82 (2.4)
Sweden	611 (9.6)	23 (6.6)	388 (11.4)	200 (7.8)	465 (13.8)
Germany	766 (12.1)	36 (10.4)	412 (12.1)	318 (12.4)	345 (10.2)
Hungary	931 (14.7)	36 (10.4)	497 (14.5)	398 (15.5)	501 (14.8)
Spain	356 (5.6)	15 (4.3)	224 (6.6)	117 (4.6)	249 (7.4)
Highest educational level of parents, *n* (%)					
Low	269 (4.3)	13 (3.8)	128 (3.8)	128 (5.0)	143 (4.2)
Medium	2,746 (43.3)	136 (39.2)	1,464 (42.8)	1,146 (44.6)	1,433 (42.4)
High	3,321 (52.4)	198 (57.1)	1,825 (53.4)	1,298 (50.5)	1,803 (53.4)
Duration of electronic media use (TV + PC) (hr per day), median (interquartile range)	2.0 (1.3–3.0)	1.5 (1.0–2.2)	1.9 (1.2–2.8)	2.5 (1.5–3.6)	2.1 (1.3–3.2)
Pubertal status (pubertal), *n* (%)	2,217 (35.0)	0	337 (9.9)	1,880 (73.1)	1,280 (37.9)

Note. SD, standard deviation; hr, hours.
[a]Calculated only for those who napped.

TABLE 2 Cross-sectional associations between well-being (exposure) and sleep characteristics (outcomes) in 2013/14 in the whole group and stratified by age

	Nocturnal sleep duration z-score											
	Whole group N = 6,336			Preschool children N = 347			Primary school-aged children N = 3,417			Adolescents N = 2,572		
	β	95% CI	p	β	95% CI	p	β	95% CI	p	β	95% CI	p
Well-being score[a]												
Model 1[b]	0.041	0.022–0.060	<0.001	−0.023	−0.121 to 0.075	0.64	0.036	0.010–0.061	0.006*	0.054	0.026–0.082	<0.001
Model 2[c]	0.031	0.011–0.050	0.002*	−0.019	−0.119 to 0.082	0.72	0.026	0.000–0.052	0.05	0.045	0.016–0.074	0.003*
	Trouble getting up in the morning											
	Whole group N = 6,336			Preschool children N = 347			Primary school-aged children N = 3,417			Adolescents N = 2,572		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Well-being score[a]												
Model 1	0.73	0.69–0.77	<0.001	0.67	0.51–0.89	0.006*	0.69	0.63–0.74	<0.001	0.78	0.74–0.83	<0.001
Model 2[d]	0.76	0.72–0.80	<0.001	0.72	0.54–0.96	0.03*	0.71	0.66–0.77	<0.001	0.81	0.76–0.86	<0.001
	Difficulties falling asleep											
	Whole group N = 6,336			Preschool children N = 347			Primary school-aged children N = 3,417			Adolescents N = 2,572		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Well-being score[a]												
Model 1	0.70	0.65–0.74	<0.001	0.65	0.46–0.91	0.01*	0.68	0.62–0.75	<0.001	0.72	0.66–0.79	<0.001
Model 2[e]	0.73	0.69–0.78	<0.001	0.70	0.50–0.99	0.04*	0.73	0.66–0.80	<0.001	0.75	0.68–0.82	<0.001

Note. All models were adjusted for age, sex, country, highest educational level of parents and duration of electronic media use. All models conducted with the whole group were further adjusted for self- versus proxy-report, pubertal status and included a random effect for family affiliation. All models conducted in primary school-aged children and adolescents were also adjusted for pubertal status, and included a random effect for family affiliation. If applicable, additional adjustment variables are given in the footnotes.
CI, confidence interval; OR, odds ratio.
[a]1 unit ≙ 4 points.
[b]Additionally adjusted for napping time.
[c]Additionally adjusted for napping time, trouble getting up in the morning, difficulties falling asleep.
[d]Additionally adjusted for nocturnal sleep duration z-score, difficulties falling asleep.
[e]Additionally adjusted for nocturnal sleep duration z-score, trouble getting up in the morning.
*$p \geq 0.05$ after correction for multiple testing according to Holm's sequential Bonferroni procedure (Holm, 1979).

confidence intervals (CIs) and corresponding p-values. A footnote indicates p-values exceeding 0.05 after adjustment for multiple testing according to Holm's sequential Bonferroni procedure (Holm, 1979).

3 | RESULTS

Descriptive characteristics of the cross-sectional sample are displayed in Table 1. Older participants tended to sleep shorter and to have a lower well-being score. The prevalence of having “trouble getting up in the morning” and “difficulties falling asleep” was highest in adolescents. The distributions of key variables such as sleep characteristics and well-being score were similar in both the larger cross-sectional and the smaller longitudinal analysis groups.

3.1 | Cross-sectional analysis

For every 4-point increase in the well-being score, there was a 0.041 (95% CI [0.022; 0.060]) unit increase in nocturnal sleep duration z-score (Model 1; Table 2). For example, a child with a well-being score of 46 slept on average 5–7 min longer than a child with a score of 34 (exact duration depends on age group). The age-stratified analysis showed that this association was strongest in adolescents. When sleep disturbances were included (Model 2), the association was slightly attenuated and no longer statistically significant in the whole group. Furthermore, higher well-being was associated with lower odds of having “trouble getting up in the morning” and “difficulties falling asleep” in both Model 1 and Model 2. Effect sizes were similar in the three age groups, although not statistically significant in preschoolers. Quantile regression revealed increasingly stronger associations between well-being and nocturnal sleep duration for the lower tail of the nocturnal sleep duration distribution (Figure 2).

3.2 | Longitudinal analysis

Approach A: Change in well-being score was positively associated with nocturnal sleep duration z-score at follow-up (Model 1, β for 1-

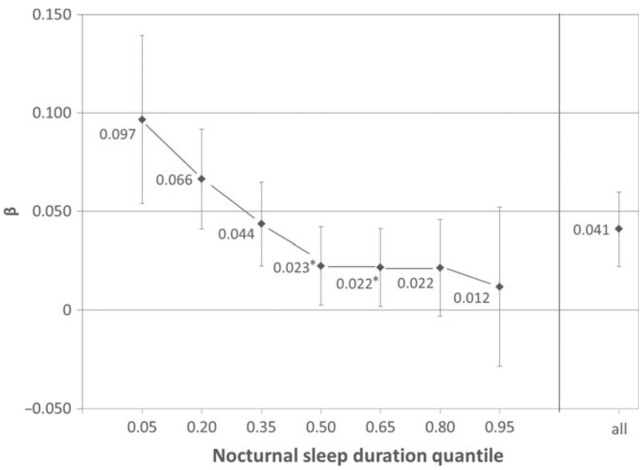

FIGURE 2 Effect estimates for well-being (β with 95% confidence interval [CI]) on different nocturnal sleep duration quantiles obtained from quantile regression adjusting for age, sex, country, highest educational level of parents, duration of electronic media use, self- versus proxy-report, pubertal status and napping time (*N=6,336*). The corresponding estimate from the linear regression is given for comparison (see also Table 2). *Denotes *p*-values ≥ 0.05 after correction for multiple testing according to Holm's sequential Bonferroni procedure (Holm, 1979)

point annual increase: 0.052 [0.028; 0.077]) (Table 3). For instance, a child with a well-being score of 34 at baseline and a well-being score of 46 after 4 years of follow-up slept on average 6–11 min longer at follow-up compared with a child with no improvement in well-being. The effect was marginally stronger in adolescents compared with primary school-aged children. Change in well-being score was negatively associated with "trouble getting up in the morning" and "difficulties falling asleep" at follow-up.

Approach B: There was a negative association between well-being score at baseline and sleep duration *z*-score at follow-up (Model 1, β for 4-point increase: −0.030; [−0.058; −0.002]) (Table 4) that was no longer statistically significant after adjustment for multiple testing. On the contrary, associations between well-being score at baseline and the two indicators of sleep disturbances at follow-up both showed the expected direction where only the association between well-being score at baseline and "trouble getting up in the morning" at follow-up in primary school-aged children (Model 1) reached statistical significance.

In general, further adjustment for sleep characteristics other than the respective outcome of interest (Model 2) did not markedly change the results in any of the longitudinal models.

3.3 | Additional analyses

Estimates of the models using weekday nocturnal sleep duration *z*-score were similar to those obtained with the average nocturnal sleep duration *z*-score. In contrast, models using weekend sleep duration *z*-score generated smaller effect estimates (Tables S2–S4).

Sleep duration *z*-score at baseline was not associated with well-being score at follow-up (Table S6). With respect to the two indicators for sleep disturbances, especially "trouble getting up in the morning" at baseline predicted lower well-being at follow-up. The association appeared to be specifically strong in primary school-aged children.

The slightly negative association between well-being score at baseline and nocturnal sleep duration *z*-score approximately 4 years later was an unexpected finding. As our cross-sectional quantile regression analysis showed stronger associations at the lower tail of the nocturnal sleep duration distribution, we suspected that the longitudinal association might also be non-linear and estimated the model stratified by nocturnal sleep duration quartiles at follow-up (Table S5). A positive association between well-being and nocturnal sleep duration was found in children having short sleep at follow-up (first quartile of nocturnal sleep duration *z*-score), no association in those with medium sleep duration (second and third quartile), and a negative association, though not being statistically significant, in those with long sleep duration (fourth quartile). The same analysis was conducted stratified by age group revealing that this negative association was mainly present in adolescents with long sleep duration.

4 | DISCUSSION

This study demonstrated that higher psychosocial well-being was associated with longer nocturnal sleep duration and lower levels of sleep disturbances in European children and adolescents. Further, positive changes in psychosocial well-being were associated with improvements in these sleep characteristics over a 4-year period. In contrast, higher baseline psychosocial well-being was predominantly not associated with the considered sleep characteristics after 4 years. In general, associations between well-being and sleep disturbances appeared to be more consistent across the different analytical approaches and age groups. Further, associations persisted in most cases after adjustment for nocturnal sleep duration. In contrast, associations between well-being and nocturnal sleep duration were less robust. Effect sizes for the latter were generally small. However, our cross-sectional quantile regression showed that the association was much stronger at the lower quantiles of the nocturnal sleep duration distribution compared with the higher ones. For instance, the effect estimate at the fifth nocturnal sleep duration quantile was twice as high as the effect estimate obtained from the linear regression. These results indicate that in children/adolescents with very short nocturnal sleep duration the association between well-being and nocturnal sleep duration appears to be particularly strong. In this cross-sectional quantile regression we considered well-being as the exposure and sleep duration as the outcome. If this assumption holds true, these children may benefit most from an improvement of their well-being.

The negative association between higher well-being at baseline and shorter sleep duration at follow-up was unexpected. However, our additional analysis suggested that the association was not consistently negative across the different strata of nocturnal sleep duration at follow-up. Especially in participants with short sleep duration the association was positive and therefore agrees with our cross-

TABLE 3 Longitudinal associations between change in well-being between baseline (2009/10) and follow-up (2013/14), and sleep characteristics at follow-up (2013/14) in the whole group and stratified by age

	Nocturnal sleep duration *z*-score at follow-up								
	Whole group *N* = 3,379			Primary school-aged children *N* = 1,847			Adolescents *N* = 1,532		
	β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*
Δ Well-being score[a]									
Model 1[b]	0.052	0.028–0.077	<0.001	0.045	0.011–0.079	0.01*	0.051	0.016–0.086	0.005*
Model 2[c]	0.042	0.017–0.067	0.001	0.038	0.004–0.073	0.03*	0.042	0.005–0.078	0.03*
	Trouble getting up in the morning at follow-up								
	Whole group *N* = 3,379			Primary school-aged children *N* = 1,847			Adolescents *N* = 1,532		
	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
Δ Well-being score[a]									
Model 1[d]	0.72	0.66–0.77	<0.001	0.73	0.64–0.83	<0.001	0.73	0.63–0.83	<0.001
Model 2[e]	0.74	0.69–0.80	<0.001	0.75	0.67–0.85	<0.001	0.75	0.66–0.86	<0.001
	Difficulties falling asleep at follow-up								
	Whole group *N* = 3,379			Primary school-aged children *N* = 1,847			Adolescents *N* = 1,532		
	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
Δ Well-being score[a]									
Model 1[f]	0.71	0.65–0.78	<0.001	0.71	0.61–0.83	<0.001	0.74	0.68–0.81	<0.001
Model 2[g]	0.75	0.68–0.82	<0.001	0.76	0.65–0.88	<0.001	0.77	0.70–0.85	<0.001

Note. All models were adjusted for well-being score, age, sex, country, highest educational level of parents, duration of electronic media use (all at baseline), pubertal status (at follow-up) and included a random effect for family affiliation. All models conducted with the whole group were further adjusted for self- versus proxy-report. If applicable, additional adjustment variables are given in the footnotes.

CI, confidence interval; OR, odds ratio.

[a]1 unit ≙ 1 point per year.

[b]Additionally adjusted for nocturnal sleep duration *z*-score (at baseline), napping time (at follow-up).

[c]Additionally adjusted for nocturnal sleep duration *z*-score (at baseline), napping time (at follow-up), trouble getting up in the morning (at follow-up), difficulties falling asleep (at follow-up).

[d]Additionally adjusted for trouble getting up in the morning (at baseline).

[e]Additionally adjusted for trouble getting up in the morning (at baseline), nocturnal sleep duration *z*-score (at follow-up), difficulties falling asleep (at follow-up).

[f]Additionally adjusted for difficulties falling asleep (at baseline).

[g]Additionally adjusted for difficulties falling asleep (at baseline), nocturnal sleep duration *z*-score (at follow-up), trouble getting up in the morning (at follow-up).

*$p \geq 0.05$ after correction for multiple testing according to Holm's sequential Bonferroni procedure (Holm, 1979).

sectional findings. Hence, interpreting the effect estimate obtained from the non-stratified model might be misleading. The tendency for a negative association observed in adolescents who sleep comparably long at follow-up might be plausible. It has been claimed previously that sleep duration self-reported by adolescents might be biased such that they report time in bed rather than actual sleep duration (Arora, Broglia, Pushpakumar, Lodhi, & Taheri, 2013). High well-being comprises amongst others feeling active and doing things with friends. Thus, we may speculate that in adolescents spending a lot of time in bed, increased well-being results in lower reported sleep duration. This subgroup effect may not fully account for the negative association observed for the whole group in our main analysis. However, it has to be considered that the longitudinal analysis is complicated by change in reporting mode from proxy- to self-report, and further by the long follow-up time covering important developmental periods such as the transition from preschool to primary school and the transition from childhood to adolescence during which sleep habits may change considerably (decrease in nocturnal sleep duration, changes in daytime napping and chronotype, etc.).

With regard to the additional analysis, it is noteworthy that children's well-being was more strongly associated with weekday nocturnal sleep duration compared with weekend nocturnal sleep duration, i.e. those with higher well-being tended to sleep longer especially during the week.

4.1 | Comparison with previous research results

Sleep problems, morning tiredness and difficulties going to sleep were found to be cross-sectionally associated with poorer psychosocial HRQoL measured with the Pediatric Quality of Life Inventory (PedsQL) in preschoolers participating in the Longitudinal Study of Australian Children (LSAC; Hiscock et al., 2007). We also observed an association between well-being and sleep disturbances in this young age group. However, the effect estimate was statistically non-

TABLE 4 Longitudinal associations between well-being at baseline (2009/10) and sleep characteristics at follow-up (2013/14) in the whole group and stratified by age

	Nocturnal sleep duration *z*-score at follow-up								
	Whole group *N* = 3,379			Primary school-aged children *N* = 1,847			Adolescents *N* = 1,532		
	β	95% CI	*p*	β	95% CI	*p*	β	95% CI	*p*
Well-being score at baseline[a]									
Model 1[b]	−0.030	−0.058 to −0.002	0.04*	−0.015	−0.053 to 0.023	0.44	−0.032	−0.074 to 0.011	0.14
Model 2[c]	−0.035	−0.063 to −0.006	0.02*	−0.020	−0.059 to 0.018	0.29	−0.034	−0.077 to 0.008	0.11
	Trouble getting up in the morning at follow-up								
	Whole group *N* = 3,379			**Primary school-aged children *N* = 1,847**			**Adolescents *N* = 1,532**		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Well-being score at baseline[a]									
Model 1[d]	0.90	0.83–0.97	0.008*	0.80	0.70–0.91	0.001	0.98	0.88–1.08	0.62
Model 2[e]	0.91	0.84–0.98	0.02*	0.82	0.72–0.93	0.002*	0.98	0.89–1.09	0.72
	Difficulties falling asleep at follow-up								
	Whole group *N* = 3,379			**Primary school-aged children *N* = 1,847**			**Adolescents *N* = 1,532**		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Well-being score at baseline[a]									
Model 1[f]	0.89	0.81–0.98	0.02*	0.81	0.68–0.97	0.02*	0.95	0.85–1.07	0.37
Model 2[g]	0.90	0.82–0.99	0.04*	0.85	0.71–1.01	0.06	0.95	0.85–1.07	0.40

Note. All models were adjusted for age, sex, country, highest educational level of parents, duration of electronic media use (all at baseline), pubertal status (at follow-up), follow-up time and included a random effect for family affiliation. All models conducted with the whole group were further adjusted for self- versus proxy-report. If applicable, additional adjustment variables are given in the footnotes.
CI, confidence interval; OR, odds ratio.
[a]1 unit ≙ 4 points.
[b]Additionally adjusted for nocturnal sleep duration *z*-score (at baseline), napping time (at follow-up).
[c]Additionally adjusted for nocturnal sleep duration *z*-score (at baseline), napping time (at follow-up), trouble getting up in the morning (at follow-up), difficulties falling asleep (at follow-up).
[d]Additionally adjusted for trouble getting up in the morning (at baseline).
[e]Additionally adjusted for trouble getting up in the morning (at baseline), nocturnal sleep duration *z*-score (at follow-up), difficulties falling asleep (at follow-up).
[f]Additionally adjusted for difficulties falling asleep (at baseline).
[g]Additionally adjusted for difficulties falling asleep (at baseline), nocturnal sleep duration *z*-score (at follow-up), trouble getting up in the morning (at follow-up).
*$p \geq 0.05$ after correction for multiple testing according to Holm's sequential Bonferroni procedure (Holm, 1979).

significant due to the small sample size, although effect estimates were similar to those for the two older age groups. Also in agreement with our findings, Roeser et al. (2012) reported lower scores on the Sleep Disturbance Scale for Children to be cross-sectionally associated with higher HRQoL measured with the KINDL[R] questionnaire in a small sample of German adolescents (*N* = 92). Comparable to our findings, children's mild and moderate/severe sleep problems were cross-sectionally associated with lower HRQoL measured with the PedsQL in 6–7-year-old participants of the LSAC (Quach et al., 2009). Consistently, a further study based on another wave of the LSAC data with in-depth sleep assessment showed that 10–11-year-old children categorized as having disordered sleep, i.e. amongst others experiencing difficulties falling asleep, morning tiredness and/or frequent nocturnal awakenings, had concurrently lower scores on all four subscales of the PedsQL compared with those categorized as having good sleep, i.e. sufficient sleep duration and good sleep quality according to self-reports (Magee et al., 2017).

As it becomes clear from the description of these cross-sectional results, most researchers assumed sleep to influence HRQoL and not the other way round. Although some longitudinal studies reported aspects of mental ill-health such as depression and anxiety to predict sleep (Johnson, Roth, & Breslau, 2006; Kelly & El-Sheikh, 2014; Roberts & Duong, 2014), we are not aware of any longitudinal study that investigated the influence of HRQoL or a measure spanning several subdomains of HRQoL as done in our study on sleep.

4.2 | Strengths and limitations

One of the major strengths of our study is the detailed longitudinal analysis. With models such as those according to analytical approach B, the direction of the association can be examined. However, as mentioned earlier, 4 years is a very long follow-up time—especially in growing children and adolescents—and hence it might be that there are effects of psychosocial well-being on sleep that are acting over shorter time periods. Models as those according to analytical approach A take this into account by calculating change in the exposure rather than only using the baseline value of the exposure. Making a statement regarding the direction of the association from such models in which change in the exposure is modelled against change in the outcome is not possible. We focussed on the potential influence of well-being on sleep duration and indicators of sleep disturbances because this has rarely been investigated so far. Nevertheless, it is possible that the association is bidirectional and that sleep characteristics may also affect well-being. Thus, reverse causality cannot be excluded in the cross-sectional analysis and the longitudinal analysis following analytical approach A. Reversing the models according to analytical approach B in an additional analysis, i.e. using sleep characteristics at baseline as the exposure and well-being at follow-up as the outcome, only revealed weak associations. Hence, our longitudinal results did not suggest one direction of the association to be more pronounced than the other.

Further strengths of our study are the standardized data collection from a large sample of European children and adolescents, and consideration of multiple sleep characteristics. Nevertheless, our study had the limitation that sleep and well-being were subjectively and not objectively measured. In general, sleep duration is overestimated when obtained from questionnaires compared with accelerometry (Arora et al., 2013), and both sleep duration and HRQoL reported by parents are overestimated compared with self-reports (Jozefiak, Larsson, Wichstrom, Mattejat, & Ravens-Sieberer, 2008; Short, Gradisar, Lack, Wright, & Chatburn, 2013). However, we assume these measurement errors most likely to be non-differential. It is likely that such misclassification would have resulted in an underestimation of the effect sizes rather than introducing spurious associations. Further, to control for potential differences in reporting of well-being, sleep measures and potential confounders, we included an indicator for proxy- versus self-report in our analyses. Lastly, our assessment of sleep disturbances was rather simple (disturbances present yes versus no). A more detailed assessment, for example, inquiring about the frequency of the occurrence and severity of the disturbances, would have allowed us to investigate the association between well-being and sleep disturbances in more depth.

5 | CONCLUSIONS

Our study confirms findings of previous studies by showing higher psychosocial well-being, covering aspects of emotional well-being, self-esteem and social relationships, to be cross-sectionally associated with longer sleep duration and especially fewer sleep disturbances in European children and adolescents. We add further evidence for this by demonstrating that associations between higher psychosocial well-being and fewer sleep disturbances were consistent across three age groups (preschool children, primary school-aged children and adolescents). Further, our study is one of very few studying the longitudinal association between well-being and sleep characteristics. We showed that an improvement in well-being over time was longitudinally associated with improvements in sleep characteristics. However, our study provides only weak evidence that well-being measured at one point in time has an effect on sleep characteristics several years later. Hence, well-being and sleep may influence each other mainly over short time periods.

CONFLICTS OF INTEREST

All authors have no conflicts of interest to disclose.

AUTHOR CONTRIBUTIONS

BFT conceptualized and designed the study, and carried out the initial analyses. CB, WA and JK assisted with conceptualization and/or interpretation of data analyses. LR and WG contributed to the design of the data collection instruments. TV, AS, LAM, NM, FL, MH, RF and SDH contributed to the acquisition of data. BFT drafted the initial manuscript, and all other authors reviewed and revised it. All authors approved the final manuscript as submitted.

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