Published in final edited form as:

Disabil Rehabil. 2014 ; 36(25): 2136–2142. doi:10.3109/09638288.2014.892639.

Walking activity of children with cerebral palsy and children developing typically: a comparison between the Netherlands and the United States

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Abstract

Purpose—To compare walking activity of children with and without cerebral palsy (CP) between the Netherlands and the United States.

Methods—A cross-sectional analysis on walking activity data from an international retrospective comparison study including a convenience sample of 134 walking children aged 7–12 years with spastic CP, classified as Gross Motor Function Classification System (GMFCS) level I ($N = 64$), II ($N = 49$) or III ($N = 21$), and 223 typically developing children (TDC) from the Netherlands and the United States. Walking activity was assessed during a one-week period using a StepWatch™ activity monitor. Outcomes were the daily number of strides, daily time being inactive and spent at low (0–15 strides/min), moderate (16–30 strides/min) and high stride rate (31–60 strides/min). Walking activity was compared between countries using multiple linear regression analyses.

Results—Walking activity of TDC was not significantly different between countries. Compared to their American counterparts, Dutch children in GMFCS level I and II showed less walking activity ($p < 0.05$), whereas Dutch children in GMFCS level III showed more walking activity ($p < 0.05$).

Conclusion—The absence of differences in walking activity between Dutch and American TDC, and the presence of differences in walking activity between Dutch and American children with CP suggest that between-country differences affect walking activity differently in children with CP.

Keywords

Cerebral palsy; children; environment; motor activity; physical activity

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Declaration of interest

The authors report no declarations of interest.

Introduction

Physical inactivity has become the fourth leading cause of mortality in the world, resulting in world-wide attention for the promotion of physical activity already at young age [1]. Stimulating an active lifestyle is especially important for children with cerebral palsy (CP), who often experience challenges with participating in physical activities [2]. CP is the most common cause of physical disabilities in pediatric rehabilitation [3]. It is an umbrella term for disorders in the development of movement and posture, causing activity limitations, as a result of non-progressive disturbances in the infant brain [4].

Previous studies have shown decreased physical activity of children with CP compared to children developing typically in both the Netherlands [5] and the United States [6], with widening gaps when mobility problems increase [6,7]. Furthermore, Dutch children with CP have been shown to walk less during the weekend than during schooldays [7], suggesting other influencing factors apart from the disease characteristics. Although physical activity levels of children with CP have been reported for the Netherlands [7–10], the United States [11,12], and Australia [13,14] separately, no direct comparisons between countries have been made yet. This might be due to the varying assessment methods used (questionnaires, pedometers, doubly-labeled water technique and activity monitors), and the inclusion of different age categories. Increased understanding of differences in physical activity between countries may provide insight into other characteristics, next to disease characteristics, that may influence physical activity of children with CP. This may offer useful information for the development of activity stimulation programs for children with CP.

Methods to assess physical activity can be divided into subjective and objective methods. Subjective instruments, such as questionnaires, rely on self-reported physical activity, they are cheap and they are easy in their use. These advantages have to compete against the disadvantages of socially desired answering and recall bias [15]. In particular, the short bursts of activities at high intensity, which are typical during childhood [16], may be hard to recall. Furthermore, cultural differences may influence the interpretation of the questionnaires, which hinders comparison of physical activity between different countries [17]. The objective and real-time assessment of physical activity by means of activity monitoring has been suggested to address these limitations [17,18]. A device that has been used to assess walking activity of children with CP is the StepWatch™ Activity Monitor (StepWatch™, Orthocare Innovations, Seattle, WA) [6,7,12]. This ankle-worn bi-axial accelerometer registers strides per self-selected time interval, also providing information on the intensity of walking during the day. The advantage of this device is the ability to adjust the sensitivity settings of the accelerometer to accurately register strides for the pathological walking patterns as found in children with CP.

Although between-country differences in physical activity have not yet been studied in children with CP, activity levels of children who are developing typically show large discrepancies between countries [19,20]. This suggests that cultural and political differences may influence children's physically active behavior. In the Netherlands, physical activity of children developing typically has been reported to be associated with environmental characteristics, such as more green space and less heavy traffic in the neighborhood [21].

American children have been repeatedly shown to have lower physical activity levels compared to European children [19]. Possible explanations provided by these authors are the American car-oriented lifestyle and environment, while European environments are more designed for walking and biking [19]. In addition, Vincent et al. [22] explained their higher physical activity levels in Swedish children compared to Americans by the different organization of school day-activity (less in-class time and more activity breaks in Sweden), and more participation in after-school sports clubs in Sweden. Apparently, environmental and political differences influence physical activity levels of children developing typically. Whether this also counts for children with CP is not yet investigated, illustrating the need for the present study.

The primary aim of this study is to compare walking activity on school days and on weekend days of children with CP and an age- and gender-matched sample of children developing typically between the Netherlands and the Pacific Northwest of the United States. We hypothesize that children with CP, like children developing typically, are more active in the Netherlands than in the Pacific Northwest of the United States.

Methods

Design

A cross-sectional analysis on data from an international retrospective comparison study was conducted. This study combined Dutch and American walking activity data, assessed with a StepWatch™ activity monitor (see below), of children with spastic CP and children developing typically in the age of 7–12 years. Both countries used a convenience sample. The Dutch walking activity data of children with CP was collected during the baseline assessments of a trial evaluating either a physical activity stimulation program [23], or a lower extremity strength training for children with spastic CP aged 7–12 years [24]. The American data were derived from cross-sectional studies on walking activity in the Pacific Northwest of the United States among children with CP aged 2–13 years [6,11]. In both countries the children developing typically were matched to the children with CP based on age and gender [25]. Walking activity data were collected between 2004 and 2012. All Dutch studies were approved by the Medical Ethical Board of the VU University Medical Center Amsterdam in the Netherlands. The American studies were approved by the Institutional Research Board of the Seattle Children's Research Institute. All parents, and children aged 12 years and older, agreed upon voluntary participation in these studies and signed an informed consent.

Participants

The inclusion criteria for this comparison study were: age 7 to 12 years, having spastic CP, and being able to walk independently with or without aids as classified in level I–III on the five-level Gross Motor Function Classification System (GMFCS; GMFCS I: Walking without limitations; GMFCS II: Walking with limitations; GMFCS III: Walking with a hand-held mobility device; GMFCS IV: Self-mobility using a wheelchair; GMFCS V: No independent mobility, being transported) [26]. General exclusion criteria were: contra-indications for physical training, instable seizures and surgery in the past 6 months. Children

were included in the analysis if walking activity was recorded for a minimum of four days, of which at least one weekend day.

Outcome measures

Walking activity was assessed with the StepWatch™ Activity Monitor 3.0 (StepWatch™, Orthocare Innovations, Seattle, WA), which is an ankle-worn bi-axial accelerometer registering accelerations of one leg in the frontal and sagittal plane per time interval. The psychometric properties of the StepWatch™ have been shown to be good in children developing typically [27–29]. By sensitivity-adjusted calibration, performed as previously described, the StepWatch™ can also accurately record steps of one leg for children with CP [6,7]. The number of strides per day, the time (min) spent being inactive and at low stride rate (0–15 strides/min), time spent at moderate stride rate (16–30 strides/min), and time spent at high stride rate (31–60 strides/min) during a 24-h day were used for analyses [7,30], and will be further referred to as walking activity.

Additional measures

The participants' personal characteristics included GMFCS level, age, gender and school type (regular school or special school for children with a disability). The environmental characteristics comprised maternal educational level and assessment season. Maternal education of the included children was categorized as low (maximal a vocational degree) or high (minimal college degree or university degree). Assessment season was based on the date of measurement and determined as spring (March–May), summer (June–August), autumn (September–November), and winter (December–February). For a subset of children with CP aged 7–9 years, information was available on mobility capacity: gross motor capacity measured with the Gross Motor Function Measure-66 item sets [31], and walking capacity measured with the one-minute walk test [32].

Procedure

After calibration, the StepWatch™ was programmed to record the number of strides per minute, so enabling registration of walking activity for a maximum of 15 days. All children were instructed to wear the StepWatch™ during all waking hours, except for bathing and swimming, for at least seven days including the weekend. Children and parents were provided with verbal, written and visual information on how to wear the StepWatch™ around the ankle: The StepWatch™ was worn on the right leg, except for Dutch children with CP who wore it on the least affected leg. In both countries, parents and/or children registered in a diary when the StepWatch™ was worn enabling us to determine which days were representative for the child's walking activity.

A minimum of 10 h StepWatch™ wearing time was required for schooldays, and a minimum of eight hours for weekend days. Days with more than three hours of consecutive missing data were excluded. After this selection process, all 24-h data were processed in R statistical software version 2.15.0 (The R foundation for Statistical Computing 2012, www.r-project.org) to calculate daily walking activity, and to label representative days as school day or weekend day using the date of measurement. With this information, mean walking activity was calculated for a typical schoolday, a weekend day, and for an average

week day (scaled as 4/5 school day and 1/5 weekend day to enable comparison with previous work).

Data analysis

Post-hoc power calculations for each GMFCS level were based on the number of children, and observed standard deviations of the number of strides per day on school days. With a power of 80% and a significance level of 5% the detectable differences between countries were 1044 strides, 1402 strides and 1244 strides per day for children developing typically, GMFCS I and GMFCS II, respectively. No power calculation was performed for the walking activity of children classified as GMFCS level III, since their data was not normally distributed.

Personal characteristics, environmental characteristics and mobility capacity were tested for differences between countries with an independent *t*-test, Mann–Whitney *U*-test or Pearson Chi-square tests as appropriate.

To compare walking activity between countries, a multiple linear regression analysis was performed for children developing typically and for children in each GMFCS level separately, with walking activity as dependent variable, and country (0 = The Netherlands, 1 = United States) as the primary independent variable. Variables with non-normally distributed residuals were logarithmically transformed prior to performing linear regression analyses. If residuals remained skewed a non-parametric Mann–Whitney *U*-test was performed.

Gender (male or female), age (dichotomized as 7–9 years/10–12 years) and maternal education (low or high) were included as confounders in the linear regression models when they changed the regression coefficient of interest with more than 10%. All statistical procedures were performed with the Statistical Package for the Social Sciences 20.0 (IBM SPSS® Inc, Chicago, IL), with significance set at $p < 0.05$.

Results

Participants

Based on the above-mentioned criteria 134 children with spastic CP and 223 children developing typically were included in the study. The participant characteristics given in Table 1 demonstrated no significant differences in the distribution of age and gender in samples from both countries. It can be observed that all American children in this sample went to regular schools, and the majority of Dutch children in GMFCS level II and III went to special schools for children with a disability. Maternal educational level was lower in the Netherlands ($p < 0.001$) and assessment season was different between countries, particularly among children developing typically. Mobility capacity was not significantly different between both countries for the subset of children in GMFCS level III. Mobility capacity was significantly better in the Netherlands for children in GMFCS level I and II ($p < 0.05$) among the subset of children aged 7–9 years.

Walking activity

Figure 1 presents the mean walking activity for children developing typically and children in each GMFCS level on schooldays and weekend days (see also Supplementary Table 3 for more information).

On schooldays, children in GMFCS level II were less active in the Netherlands than in the United States (except for time spent at moderate stride rates), whereas children in GMFCS level III took more strides, spent less time being inactive and at low stride rate, and more time at moderate stride rate in the Netherlands than in the United States. There were no differences in walking activity between countries for typically developing children and children classified as GMFCS level I.

On weekend days, children classified as GMFCS level I took significantly less strides per day, spent more time being inactive and at low stride rate, and spent less time at moderate and high stride rates in the Netherlands than in the United States, while walking activity of typically developing children and children in the other GMFCS levels did not differ between countries.

The above described differences between countries for walking activity on either schooldays or weekend days were also found for an average weekday, except for time at moderate stride rate on an average weekday in children in GMFCS level I (Table 2).

Discussion

The aim of the study was to compare walking activity of children with CP who walk independently without (GMFCS level I and II) or with aids (GMFCS level III) and walking activity of children developing typically between the Netherlands and the Pacific Northwest of the United States. The hypothesis that children with CP, like children developing typically, would be more active in the Netherlands than in the United States was not confirmed, except for children with CP classified as GMFCS level III. Children developing typically showed no different walking activity in both countries, whereas contrary to our hypothesis children classified as GMFCS level I and II in the Netherlands generally demonstrated less walking activity than those in the United States. This is the first study comparing objectively assessed walking activity of children with CP between countries. The study design with data in both countries collected and processed in the same way, and the use of the Gross Motor Function Classification System for the categorization of children with CP regarding walking in daily life are important strengths of the study.

The lack of differences between countries for walking activity of children developing typically was contrary to our expectations, since a previous review has demonstrated that girls and boys who are developing typically take about 2375 and 2389 steps per day (equaling 1188–1195 strides per day) more in Europe than in the United States and Canada [19]. Possibly, these contrasting results are caused by the origin of our American sample of children from the Pacific Northwest, which involves some of the most active regions of the United States [33]. Thereby, the discrepancy with the literature might be due to the different monitoring devices used, since the previous studies used waist mounted pedometers

(primarily the Digiwalker, Yamax), whereas we used the ankle-worn StepWatch™ activity monitor. Nonetheless, we do not expect that these differences have substantially influenced our results, since both instruments were designed to record the number of steps or strides during walking [27–29,34]. Another explanation may be provided by the fact that there was no equal distribution across seasons of walking activity data collection among the children developing typically in both countries, since none of these Dutch children were assessed during autumn and winter. Although a previous review did not demonstrate clear influence of season on walking activity for the United States (effects of season on walking were not studied in the Netherlands), it did indicate an influence of season on walking activity in the United Kingdom, with more walking in summer than in winter [35]. Despite of walking activity of Dutch children possibly being higher as a result of data collection in spring and summer, walking activity was still not higher in the Netherlands than in the United States, suggesting that Dutch children are possibly even less active than American children who are developing typically. Nevertheless, a subgroup analysis of our walking activity data in the Dutch and American ($n = 95$) children developing typically who were only assessed in spring and summer (data not shown) did also show no differences between countries. This provides us with confidence that our results are not substantially influenced by season.

Despite no significant differences in walking activity between Dutch and American children developing typically, Dutch children in GMFCS level I and II demonstrated less walking activity, while Dutch children in GMFCS level III demonstrated more walking activity than their American counterparts. These results suggest that environmental and cultural differences between countries may play a different role among children with CP than among children developing typically. Perhaps, the different school systems in both countries account for the differences in walking activity, since 75% of the Dutch children in GMFCS level II and III in our sample went to special schools for children with a disability, whereas the United States have a federally mandated policy of integration of children within the regular schools in the local area. Previous work among children with CP did not demonstrate a difference in walking activity between regular schools and special schools within the Netherlands [7], suggesting that between-country differences in school environment (and not differences between regular and special education) are responsible for the differences in walking activity between countries among children with CP. Considering the common opinion that the United States are geographically more widely spread, American regular school complexes may include larger number of students, are therefore bigger and may provide more walking activity for children in GMFCS level I and II, relative to the Dutch group. In contrast, the smaller Dutch schools may enable children in GMFCS level III to walk independently with a walking aid during school hours, whereas the supposed large distances in American regular school complexes and possible different opinions of professionals about the use of walking aids may result in more frequent use of wheelchairs during school hours.

There were no studies to compare our between-country differences in walking activity of children with CP with. However, between European countries, variations in the difficulty of participation in daily activities have been reported among children with CP [36], as well as variations in transport, social support, attitudes and the access to the physical environment

[37]. Colver et al. [38] have demonstrated that less difficulty with mobility-related participation was associated with better transport and better access to the community environment, whereas participation in recreation was associated with better transport and better attitudes of family and friends. Similar environmental and cultural factors for participation in physical activity were identified in a Dutch qualitative study in children with CP and their parents in the Netherlands, which also indicated that most attitudinal barriers had to do with social acceptance [39]. Perhaps, the discrepancy in walking activity between Dutch and American children with CP is explained by between-country differences in transport options, access to the school environment and the social acceptance of children with a disability. However, since these environmental factors were not assessed in this study, further research is required to determine which factors can explain the reported differences.

We observed in Figure 1 that children with CP in both countries were less active than children developing typically, supporting the need for physical activity stimulation in Dutch and American children with CP. Furthermore, we observed that children with CP in the Netherlands demonstrated less walking activity on weekend days, compared to schooldays, while walking activity was the same, or more, on weekend days in the United States. This pattern was not observed in children developing typically. Information about the nature of the walking activity during school days and weekend days, as well as studying between-country environmental differences (e.g. attitude towards the inclusion of children with CP in sports, social acceptance) regarding participation in weekend-day activities may be helpful to clarify the discrepancies in the different walking activity levels on schooldays and weekend days between countries, and should be subject for further research.

Limitations should be noted in the interpretation of these results. First, the Pacific Northwest of the United States is known to be among the most active parts of the United States [33], limiting the generalizability of these findings to children in other parts of the United States. Nevertheless, because walking activity levels of children developing typically were not significantly different in these two regions (Pacific Northwest and the Netherlands), the discrepancies between countries for walking activity of children with CP offer valuable information. Another limitation is the difference in wearing position of the StepWatch between groups. The American children wore the StepWatch™ on the right leg (which may sometimes be the most impaired leg), while Dutch children wore it at the least impaired leg. This may lead to an underestimation of the walking activity of American children because the Stepwatch may not capture each step of the impaired leg due to the more shuffling gait. However, this would not affect the conclusions of the paper because it would lead to a further increase of the differences between Dutch and American children. In addition, since calibration of the StepWatch™ in both the USA and the Netherlands resulted in 95–100% accuracy, we expect that the leg on which the StepWatch™ was worn has minor influence on the total walking activity of the children. A third limitation is that the comparison between American and Dutch children in GMFCS level I and II may have been restricted by the lower mobility capacity scores found for American children in GMFCS level I and II in a subgroup aged 7–9 years. However, taking into account that walking activity decreases with decreasing mobility capacity, the demonstrated differences in walking activity between

countries would become even larger for Dutch and American children in GMFCS level I and II, thereby not influencing our conclusions.

Fourth, the results with regard to children in GMFCS level III should be interpreted cautiously, since few Dutch children in GMFCS III were included. Future research including more children in this category should be performed to confirm our results.

In conclusion, the walking activity of Dutch and American children developing typically was not different, but discrepancies between countries were found for walking activity of children with CP. This suggests that environmental between-country differences affect walking activity differently in children with CP. Future research should examine which specific environmental factors should be addressed to improve walking activity of children with CP in both countries.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors are grateful to A. Middelweerd and R. Van Rijssel who collected the data of the Dutch children who are developing typically, and E. Dillon and M. Sheiko who collected data on the American children developing typically. Dr Kit Song, MD, was a key supporter of the initial American project with children developing typically. Dr Robert Miller, MD, supported data collection of participants with cerebral palsy in the United States.

The Dutch data were collected with the financial support of ZonMw (grant number 89000002), Johanna Kinderfonds, Stichting Rotterdams Kinderrevalidatie Fonds Adriaan Stichting, Revalidatiefonds, Phelps Stichting, Revalidatie Nederland, the Nederlandse Vereniging van Revalidatieartsen, and a personal (LvW) travel grant awarded by the EMGO⁺ Institute for Health and Care Research of the VU University Medical Center Amsterdam, The Netherlands. The American data collection was supported by funding from NIH K23 HD060764, UL1RR025014 (T32 HD07424) (F31-NS048740), and by a Hester McLaws Nursing Scholarship. Staheli Endowment Fund, Clinical Steering Committee Research Award, Department of Orthopedic Surgery, Seattle Children's Hospital, University of Washington School of Medicine-Medical Student Research Training Program. All these grant providers were not involved in the design of the study, data collection, data analysis, manuscript preparation and publication decisions.

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Implications for Rehabilitation

- Physical activity of children with CP should be promoted in both the United States and the Netherlands.
- The between-country differences in walking activity illustrate that apart from the severity of the CP walking activity seems to be influenced by environmental aspects.
- In the promotion of physical activity, practitioners should pay attention to environmental barriers that families may experience for increasing physical activity.

Figure 1.

Means (95% CI) for walking activity on schooldays and weekend days among children developing typically, and children in GMFCS levels I–III. Means of children in each GMFCS level are compared between the Netherlands (NL) and the United States (USA): (A) Strides per day, (B) time spent being inactive and at low stride rate (0–15 strides/min), (C) time spent at moderate stride rate (16–30 strides/min), (D) time spent at high stride rate (31–60 strides/min). * $p < 0.05$ and † $p < 0.01$ represent significantly different walking activity between countries within each category.

Table 1

Characteristics of participants.

	NL		USA	
	<i>N</i> = 97		<i>N</i> = 260	
Age, mean				
Developing typically	40	9.92 SD 1.69	183	9.96 SD 1.76
GMFCS Level I	33	10.48 SD 1.62	31	10.34 SD 1.59
GMFCS Level II	16	9.55 SD 1.26	33	10.09 SD 1.69
GMFCS Level III	8	9.45 SD 1.27	13	10.22 SD 1.56
Gender, <i>n</i> (%) male				
Developing typically	40	20 (50.0%)	183	92 (50.3%)
GMFCS Level I	33	22 (66.7%)	31	16 (51.6%)
GMFCS Level II	16	10 (62.5%)	33	21 (63.6%)
GMFCS Level III	8	4 (50.0%)	13	4 (30.8%)
School type, <i>n</i> (%) special school				
Developing typically	40	–	183	–
GMFCS Level I	33	15 (45.5%)	31	0 (0%)
GMFCS Level II	16	12 (75.0%)	33	0 (0%)
GMFCS Level III	8	6 (75.0%)	13	0 (0%)
Maternal education, <i>n</i> (%) low				
Developing typically	39	19 (49%)	181	31 (17%) ^b
GMFCS Level I	33	19 (58%)	31	15 (48%)
GMFCS Level II	16	10 (63%)	33	16 (49%)
GMFCS Level III	8	5 (63%)	13	9 (69%)
Season, <i>n</i> (%) spring/summer/autumn/winter				
Developing typically	40	35 (87.5)/5 (12.5)/0 (0)/0 (0)	183	39 (21.3)/56 (30.6)/48 (26.2)/40 (21.9) ^b
GMFCS Level I	33	0 (0)/1 (3.0)/24 (72.7)/8 (24.2)	31	7 (22.6)/2 (6.5)/17 (54.8)/5 (16.1) ^a
GMFCS Level II	16	0 (0)/1 (6.2)/11 (68.8)/4 (25.0)	33	9 (24.2)/8 (15.2)/8 (24.2)/13 (36.4) ^a
GMFCS Level III	8	1 (12.5)/0 (0)/3 (37.5)/4 (50.0)	13	2 (15.4)/0 (0)/8 (61.5)/3 (23.1)
	<i>N</i> = 28		<i>N</i> = 27	
Gross motor capacity (score 0–100), median (min, max) ^c				
GMFCS level I	13	86.5 (79.1, 100.0)	10	86.5 (70.4, 92.1)
GMFCS level II	9	73.6 (60.1, 92.1)	12	66.9 (56.4, 84.1) ^a
GMFCS level III	6	53.5 (47.9, 65.0)	5	58.6 (45.0, 60.6)
Walking capacity (<i>m</i>), median (min, max) ^c				
GMFCS level I	13	97.0 (86.0, 117.0)	10	84.0 (70.0, 152.0) ^b
GMFCS level II	9	83.0 (58.0, 98.0)	12	68.5 (52.0, 82.0) ^b
GMFCS level III	6	54.5 (43.0, 68.0)	5	34.0 (12.0, 61.0)

NL = The Netherlands, USA = Pacific Northwest of the United States, GMFCS = Gross Motor Function Classification System.

^a $p < 0.05$,

^b
 $p < 0.01$,

^c Only assessed in children with cerebral palsy aged 7–9 years.

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Table 2

Walking activity on an average week day (mean (SD), and for GMFCS level III median (min, max)) of children developing typically and children with CP in GMFCS level I–III in the Netherlands and the United States, and differences (β , 95% CI or effect size r) between countries.

	Developing typically			GMFCS I			GMFCS II			GMFCS III		
	NL (<i>n</i> = 40) Mean (SD)	USA (<i>n</i> = 183) Mean (SD)	Difference [‡] USA – NL β (95%CI)	NL (<i>n</i> = 33) Mean (SD)	USA (<i>n</i> = 31) Mean (SD)	Difference [‡] USA – NL β (95%CI)	NL (<i>n</i> = 16) Mean (SD)	USA (<i>n</i> = 33) Mean (SD)	Difference USA – NL β (95%CI)	NL (<i>n</i> = 8) Median (min, max)	USA (<i>n</i> = 13) Median (min, max)	Difference USA – NL r, U
Strides per day	8473 (1826)	8259 (2356)	–251 ^c (–1083, 581)	5554 (1554)	6481 (2576)	1183 ^a (193, 2172) [*]	4705 (1172)	5511 (1660)	1076 ^b (200, 1935) [*]	3141 (1395, 4725)	1605 (291, 6978)	–0.46 [*]
Time at 0–15 strides/min (min) [§]	1230 (44)	1236 (60)	6 (–14, 26)	1305 (43)	1283 (66)	–29 ^d (–55, 3) [*]	1324 (35)	1306 (46)	–25 ^b (–49, –0.3) [*]	1370 (1324, 1416)	1411 (1256, 1440)	0.44 [*]
Time at 16–30 strides/min (min) [§]	104 (17)	107 (24)	4 ^c (–5, 12)	80 (26)	87 (25)	9 ^d (4, 21)	72 (18)	79 (25)	11 ^b (–3, 24)	49 (19, 74)	22 (0, 132)	–0.46 [*]
Time at 31–60 strides/min (min) [§]	101 (37)	91 (39)	OR = 0.88 (0.8, 1.0)	52 (19)	66 (41)	18 ^d (4, 33) [*]	43 (18)	52 (22)	13 ^b (1, 25) [*]	20 (5, 45)	11 (0, 51)	–0.36

NL = The Netherlands, USA = Pacific Northwest of the United States,

[‡] Adjusted for gender, age, and/or maternal educational level:

^a Adjusted for gender,

^b Adjusted for dichotomized age,

^c Adjusted for maternal educational level,

[§] Time spent in each stride rate level was calculated over a 24-h day, which equals 1440 minutes, OR = odds ratio for linear regression analyses with logarithmically transformed data,

U Non-parametric Mann–Whitney *U*-test, *r* is the non-parametric effect size calculated as *Z*/(*N*), Significant interactions are in bold text:

^{*} *p* < 0.05.