Intensity-specific validity and reliability of the Japan Public Health Center-based prospective study-physical activity questionnaire

Hiroyuki Kikuchi[a,*], Shigeru Inoue[a], Yuko Odagiri[a], Hikaru Ihira[b], Manami Inoue[b], Norie Sawada[b], Mitsuhiko Noda[c,d], Shoichiro Tsugane[b]

[a] Department of Preventive Medicine and Public Health, Tokyo Medical University, 6-1-1 Shinjuku, Shinjuku-ku, Tokyo 160-8402, Japan
[b] Epidemiology and Prevention Group, Center for Public Health Sciences, National Cancer Centre, 5-1-1 Tsukiji, Chuo-ku, Tokyo 104-0045, Japan
[c] Department of Diabetes, Metabolism and Endocrinology, Ichikawa Hospital, International University of Health and Welfare, 6-1-14 Kounodai, Ichikawa, Chiba 272-0827, Japan
[d] Department of Endocrinology and Diabetes, Saitama Medical University, 38 Moro-hongo, Moroyama-machi, Iruma-gun, Saitama 350-0495, Japan

A R T I C L E   I N F O

A B S T R A C T

The Japan Public Health Center-based prospective study- physical activity questionnaire (JPHC-PAQ) was originally developed and validated for total physical activity (total PA). However, it is uncertain whether JPHC-PAQ could also estimate intensity-specific physical activity. The present study aims to evaluate the validity and reliability of intensity-specific physical activity by the JPHC-PAQ against 24-hour activity records (24 h-R). One-hundred and ten participants were chosen from those who had enrolled in the JPHC cohort. Time spent for total PA and intensity-specific physical activity, i.e. moderate (MPA), vigorous (VPA) and moderate-to-vigorous physical activity (MVPA) was estimated by JPHC-PAQ. In addition, the volume of PA was calculated by time of each activity multiplied by intensity of activity. For validity assessment, estimated physical activities were compared with 24 h-R. For reliability evaluation, a retest was conducted 3–6 months after the first survey was answered. Moderately strong correlation between JPHC-PAQ and 24 h-R was observed for total PA estimations (Spearman's rho = 0.672). In addition, moderate correlations were found for MPA (activity time: rho = 0.345, activity volume: rho = 0.300) and MVPA (activity time: rho = 0.563, activity volume: rho = 0.672). Whereas, little association was found for VPA time and volume. As for reliability, moderately strong correlation was found for both total and intensity-specific physical activity in the test–retest (rho = 0.482–0.745). In addition to total PA, the JPHC-PAQ showed acceptable validity and reliability for intensity-specific physical activity, especially in estimating MVPA and MPA.

1. Introduction

Past epidemiological studies have shown that regular physical activity is associated with health risks (Lee et al., 2012; Kohl et al., 2012). Large epidemiological studies with long-term follow-up periods have often used physical activity questionnaires (PAQs) to quantify individual physical activity levels due to feasibility issues (Kriska et al., 1997).

The PAQs which have been used in Japanese large-sized cohort studies have been validated for total physical activity (total PA) (Sasai et al., 2018; Ishikawa-Takata et al., 2011; Hayasaka et al., 2009; Fujii et al., 2011), however these PAQs have not yet been validated for intensity-specific physical activity. Rather, moderate-to-vigorous physical activity (MVPA), which refers to activities of ≥3.0 metabolic

equivalents (METs) (Craig et al., 2003; Bull et al., 2009), is a more important measure in public health because MVPA is broadly used in physical activity guidelines not only in Japan (Miyachi, 2012; Miyachi et al., 2015), but also worldwide (Haskell et al., 2007; World Health Organization, 2010). Thus, validated and reliable PAQs including MVPA are necessary to assess health benefits while meeting guidelines.

In addition, recent studies suggest that different health benefits may be acquired with different combinations of intensity-specific physical activities even with an equivalent total PA level. For example, several studies investigated whether vigorous-intensity physical activity (VPA) showed larger health benefits than moderate-intensity physical activity (MPA) after adjusting total PA (Kubota et al., 2017; Gebel et al., 2015). Furthermore, recent studies showed health risks/benefits given by sedentary behavior (SB) or light physical activity (LPA) (Owen et al.,

2010; Amagasa et al., 2018). These findings imply that physical activity should be regarded as not only total PA but also intensity-specific physical activity.

The Japan Public Health Center-based prospective study- PAQ (JPHC-PAQ) was originally developed and used in the JPHC Study, a prospective follow-up study conducted widely throughout Japan that investigated associations between life-style factors and the incidence of or mortality from cancer and other diseases (Tsugane and Sawada, 2014). As seen in the previous study (Fujii et al., 2011), the JPHC-PAQ can be used to evaluate total PA. However, it is uncertain whether or not it could also be used to estimate intensity-specific physical activity accurately. If the JPHC-PAQ has sufficient validity and reliability for measuring intensity-specific physical activity, it may be useful to assess more detailed health impacts in the JPHC study. For example, a study using this PAQ can distinguish which MPA such as walking or VPA such as running has more health benefits in equivalent amounts of activity volume.

The present study aims to investigate the validity and reliability of intensity-specific physical activity, estimated by JPHC-PAQ.

2. Methods

2.1. Study participants

Since this study used the same dataset as the original validation study, detailed information is described in the original study (Fujii et al., 2011). In brief, the four areas (i.e. Katsushika in Tokyo, Miyako in Okinawa, Saku in Nagano and Kashiwazaki in Niigata) were initially chosen in aiming to include both rural and urban areas, both western and eastern parts of Japan and both cold and subtropical areas. The potential participants (i.e. those who had enrolled in the JPHC cohort in these four areas) were contacted in convenience, and the 110 participants were finally chosen. Due to this convenience sampling, married couples in their 50 s or 60 s of shopkeepers or farmers were more likely to be selected.

Approval for the study was obtained from the Institutional Review Board of the National Cancer Center (approval date: 2001/10/18, number: 2001–021) and the Tokyo Medical University (approval date: 2019/11/30, number: T2019-0173).

3. Calculation of physical activity

Participants were asked about their activities in each of these domains during the preceding year. With regard to occupational and household activity, including transportation, they were asked about the number of hours spent at different levels of intensity (sitting, standing, walking, strenuous work); and for leisure-time activity about the frequency and number of hours spent at different levels of intensity (walking slowly, walking quickly, light to moderate and strenuous exercise). A question about sleeping hours was also asked. Hours for other activities were calculated by subtracting the sum of time for sleep/leisure/occupational/household activities from 24 h.

This study assigned 1.3, 2.0, 3.0, 6.0 METs for sitting, standing, walking and strenuous work for occupational activities, respectively. For leisure-time activities, this study assigned 2.8, 4.0, 3.0 and 6.0 METs for walking slowly, walking quickly, light to moderate exercise, and strenuous exercise, respectively. In addition, 0.9 METs was assigned for sleep. In the JPHC-PAQ, the item "other activities" aimed to measure general sitting time (Fujii et al., 2011). Currently, 1.5 METs is defined as the threshold-intensity between sedentary behavior and light physical activity (Tremblay et al., 2017). Thus, we assigned 1.3 METs for "other activities".

These assigned MET values were not exactly the same as the original study (Fujii et al., 2011), which aimed to assess validation to the total physical activity volume. Certainly, these assigned values used to be acceptable to validate against total physical activity volume (Albanes

et al., 1990). However, their assignments of intensity for several items were not in line with current physical activity research, which focused more on intensity-specific physical activity (Craig et al., 2003; Bull et al., 2009). This study aimed to validate not only for total, but also for intensity-specific physical activity, therefore, this study re-assigned the intensity of activity for each item using globally accepted values in current physical activity studies.

Finally, total PA was calculated by the sum of each length of time spent for the respective activity multiplied by the assigned METs. Then, total MVPA was also calculated considering only activities of 3.0 METs or higher intensity.

4. Other study settings

According to the original validation study, the present study used 24-h activity record (24 h-R) as the gold measure (Fujii et al., 2011). Based on established protocol (Naito, 1994; Bouchard et al., 1983), participants were asked to record activities for each 15-min interval for at least four days. The data was converted into MET-hours based on a compendium of physical activity (Ainsworth et al., 2000).

On the first day, participants were asked to complete the PAQ and then given instructions on filling 24 h-R for the following 4 days. On day 9, the 24 h-R were collected and researchers checked their response in person. These tests were conducted from October 2003 to February 2004. Then, a retest was conducted 3–6 months after the first survey was answered (i.e. March 2004 to May 2004) for reliability assessment. This 3–6 month interval was set to avoid a "learned" response of the initial test at retest (Meyer et al., 2009).

4.1. Statistical analysis

The validity of the PAQ was determined by comparing the MVPA estimated by JPHC-PAQ to that by the 24 h-R. Comparisons were made by Spearman's correlation coefficients (Spearman's rho) with 95% confidence intervals (95%CI). To examine reliability, the MET-hours estimated by the two PAQs administered at different times were compared by calculating Spearman's rho. In addition, to assess intensity-specific validity and reliability, correlation coefficients with the 24 h-R were calculated for MPA and VPA. Then, participants were divided into four groups, based on quartiles for intensity-specific physical activities by the JPHC-PAQ or 24 h-R, then, the frequencies of participants in the same, same and adjacent, and opposite quartiles of two methods were estimated. Finally, gender-stratified analyses for reliability and validity of intensity-specific physical activity were performed. All analyses were performed using Stata software version 15 (Stata Corporation, College Station, TX, USA).

5. Results

5.1. Characteristics of study participants

Characteristics of study participants are shown in Table 1. In total, 110 participants (men: 48.2%) were included in the analysis. Mean (± standard deviation, range) of age and body mass index are 60.7 (± 5.84, 45–77) years and 24.2 (± 3.18, 18.7–41.2) kg/m^2, respectively. The 40% of the participants were shopkeepers.

Table 2 shows the time and volume of each activity. The mean time of occupational/ household and leisure-time activities were 12.3 and 0.6 h per day, and the mean volume of activities in occupational/ household and leisure-time were 30.6 and 1.8 MET-hours per day, respectively. Occupational activities accounted for 50.2 percent of total time and 80.5 percent of total volume of activity.

6. Validity and reliability of the Intensity-specific JPHC-PAQ

Table 3 shows PA time and volume estimated by JPHC-PAQ and

Table 1
Characteristics of study participants.

		n
Total		110
Gender	Men	53
	Women	57
Age	50–59	45
	60–69	56
	70–79	9
Current job	Clerk	17
	Shopkeeper	44
	Housewife	20
	Agriculture	29
Area	Katsushika	20
	Miyako	38
	Saku	30
	Kashiwazaki	22

Data were obtained simultaneously with the survey of Japan Public Health Center-based Cohort Study in 2003–2004.

24 h-R, and it also shows Spearman's correlation coefficients between the two. Total MPA, VPA and MVPA volume was 11.11, 7.90 and 19.02 MET-hours per day for JPHC-PAQ and 9.23. 0.62, 9.85 MET-hours per day for 24 h-R, respectively. For physical activity volume, significant correlations were observed in MPA (rho = 0.300, p < 0.01), MVPA (rho = 0.610, p < 0.001) and total PA (rho = 0.672, p < 0.001). In addition, MPA (rho = 0.345, p < 0.001) and MVPA (rho = 0.563, p < 0.001) showed significant correlations with physical activity time. Whereas, little association was found for VPA time and volume.

The cross-classification of quartiles for intensity-specific physical activities were shown in Table 4. Acceptable correlation coefficients were found for MPA and MVPA time and volume, as well as total PA volume. However, little agreement was found for time and volume of VPA. In gender-stratified analysis showed similar validity and reliability in estimating MPA, VPA and MVPA in both genders (Supplemental table).

Table 5 shows the correlation coefficients of test–retest for reliability assessment. In total, 105 participants (95.6%) reported valid data in the retest. Spearman's correlation coefficients between test–retest were 0.483 (p < 0.001), 0.482 (p < 0.001), 0.745 (p < 0.001) and 0.745 (p < 0.001) for MPA time, MPA volume, VPA time and VPA volume, respectively. In addition, significant correlations were also found for MVPA time (rho = 0.586, p < 0.001) and volume (rho = 0.637. p < 0.001).

Finally, results of gender stratified analysis were shown in Table 6. Similarly, to results of total participants, acceptable correlation

Table 3
Validity of JPHC-PAQ with 24-hour activity record.

	JPHC-PAQ		24-hour activity record		Spearman's rho	p-value
	Mean	(SD)	Mean	(SD)		
Activity volume (MET-hour/day)						
Sleep	6.10	(0.88)	6.82	(0.81)	0.394	< 0.001
SB + LPA	19.43	(3.50)	23.77	(4.99)	0.383	< 0.001
MPA	10.47	(6.67)	9.15	(7.60)	0.300	0.002
VPA	7.32	(10.11)	0.65	(1.69)	− 0.095	0.326
MVPA	17.80	(12.69)	9.80	(7.60)	0.610	< 0.001
Total PA	43.33	(9.76)	40.39	(4.85)	0.672	< 0.001
Activity time (hour/day)						
Sleep	6.78	(0.97)	7.58	(0.90)	0.398	< 0.001
SB + LPA	12.54	(2.91)	14.02	(2.16)	0.581	< 0.001
MPA	3.46	(2.19)	2.30	(1.74)	0.345	< 0.001
VPA	1.22	(1.68)	0.10	(0.27)	− 0.093	0.336
MVPA	4.68	(2.91)	2.41	(1.73)	0.563	< 0.001
Total PA	24.0		24.0		–	–

Table 4
Cross classification of quartiles for intensity-specific physical activities between the JPHC-PAQ and the 24-hour activity record.

	Same quartile	Same and adjacent quartile	Extreme quartile	Spearman's rho	p-value
Activity volume					
SB + LPA	35	70	5	0.321	< 0.001
MPA	40	64	6	0.339	< 0.001
VPA	31	60	19	− 0.075	0.436
MVPA	45	63	2	0.579	< 0.001
Total PA	55	53	2	0.542	< 0.001
Activity time					
SB + LPA	45	63	2	0.531	< 0.001
MPA	37	67	6	0.340	< 0.001
VPA	32	58	20	− 0.091	0.347
MVPA	52	55	3	0.525	< 0.001

JPHC-PAQ: Japan Public Health Center-based prospective Study- Physical activity questionnaire, SB: Sedentary behaviors, LPA: Light-intensity physical activity, MPA: Moderate-intensity physical activity, VPA: Vigorous-intensity physical activity, MVPA: Moderate-to-vigorous physical activity. Data were obtained from those in Katsushika, Miyako, Saku and Kashiwazaki city who were enrolled in the JPHC Study in 2003–2004.

Table 2
Summary statistics of activity by JPHC-PAQ.

Domain	Activity	Assigned intensity (METs)	Time (hour/day)		Volume (MET-hour/day)	
			Mean	(SD)	Mean	(SD)
Occupation /Household						
	Sitting	1.3	3.22	(2.25)	4.18	(2.92)
	Standing	2.0	4.25	(2.20)	8.49	(4.40)
	Walking	3.0	3.05	(2.11)	9.16	(6.32)
	Vigorous activity	6.0	1.19	(1.69)	7.14	(10.13)
Leisure						
	Walking slowly such as taking a walk	2.8	0.10	(0.26)	0.28	(0.73)
	Walking fast	4.0	0.10	(0.29)	0.41	(1.15)
	Exercise such as golf, gardening	3.0	0.30	(0.57)	0.91	(1.71)
	Exercise such as tennis, jogging, aerobics, and swimming	6.0	0.03	(0.11)	0.18	(0.64)
Sleep		0.9	6.78	(0.97)	6.10	(0.88)
Other [a]		1.3	4.98	(3.91)	6.47	(5.09)

JPHC-PAQ: Japan Public Health Center-based prospective Study- Physical activity questionnaire.
[a] Hours for other activities were calculated by subtracting the sum of time for sleep/leisure/occupational/household activities from 24 h.
Data were obtained from those in Katsushika, Miyako, Saku and Kashiwazaki city who were enrolled in the JPHC Study in 2003–2004.

Table 5
Reliability of the JPHC-PAQ: test–retest correlation.

	Spearman's rho	p-value
Activity volume (MET-hour/day)		
Sleep	0.520	< 0.001
SB + LPA	0.667	< 0.001
MPA	0.482	< 0.001
VPA	0.745	< 0.001
MVPA	0.645	< 0.001
Total PA	0.684	< 0.001
Activity time (hour/day)		
Sleep	0.534	< 0.001
SB + LPA	0.708	< 0.001
MPA	0.483	< 0.001
VPA	0.745	< 0.001
MVPA	0.588	< 0.001

JPHC-PAQ: Japan Public Health Center-based prospective Study- Physical activity questionnaire, SB: Sedentary behaviors, LPA: Light-intensity physical activity, MPA: Moderate-intensity physical activity, VPA: Vigorous-intensity physical activity, MVPA: Moderate-to-vigorous physical activity
Data were obtained from those in Katsushika, Miyako, Saku and Kashiwazaki city who were enrolled in the JPHC Study in 2003–2004.

coefficients were found for MPA and MVPA time and volume, as well as total PA volume in both genders.

7. Discussion

Fujii et al. originally showed validity and reliability for estimating total PA measured by JPHC-PAQ (Fujii et al., 2011). The present study extended their findings by investigating the validity and reliability of intensity-specific physical activity, and showed acceptable validity and reliability in estimating both MVPA and MPA, in addition to total PA.

Even a review of PAQ for adults suggested that no conclusion could be drawn regarding the best questionnaire (Van et al., 2010), however, the International Physical Activity Questionnaire (IPAQ) is the most broadly used for epidemiological studies. Lee et al. reviewed twenty-three studies which investigate validity between intensity-specific physical activity and the IPAQ-short form, and they reported that median correlation coefficients were 0.28 (range: −0.03, 0.47) for VPA, 0.23 (-0.03, 0.76) for MPA and 0.32 (0.15, 0.39) for MVPA (Lee et al., 2011). Past studies often used accelerometry as a gold standard measure, thus it may be difficult to compare directly. However, when considering a study reporting comparable estimation of activity volume between 24 h-R and accelerometer among middle-aged Japanese adults (Rafamantanantsoa et al., 2002), it may suggest that the JPHC-PAQ showed relatively close validity and reliability in intensity-specific physical activity measured by IPAQ.

Unexpectedly, little association was found for VPA. For one possible reason, the JPHC-PAQ may overestimate work-related VPA. The JPHC-PAQ estimated that average length of VPA was more than 1 h per day, and 98% of them were done at work. In according to a study using accelerometers, general adults engage VPA only in a few minutes per day (Troiano et al., 2008). The JPHC-PAQ uses "none" and then "less than one hour per day" as the minimum categories for work-related VPA. Possibly, participants who engaged in VPA occasionally at work were more likely to choose "less than one hour per day", rather than "none". For one possible countermeasure, replacing the category of "none" with "almost none" might modify the overestimation of VPA. In addition, it might be speculated that the participants in this study did not engage in VPA sufficiently. According to the 24 h-R, the average time of VPA was 0.10 h/day, and approximately a half (47.2 percent) of participants did not engage in any of VPA, consequently limiting the ability to detect the validity of VPA. Future studies including younger participants who are more likely to engage in VPA would be needed before concluding the JPHC-PAQ is not suitable to estimate VPA. Indeed, one study among young college students reported moderate correlation between VPA estimated by IPAQ and that estimated by accelerometer (rho = 0.47) (Dinger et al., 2006).

It is noted that acceptable validity and reliability were confirmed for MPA and MVPA measured by the JPHC-PAQ. Physical activity guidelines mainly set recommendations of MVPA in many countries (Miyachi et al., 2015; Haskell et al., 2007; World Health Organization, 2010). In addition, promoting MPA are suggested to be an appropriate strategy for promoting physical activity for physically inactive population due to its feasibility (Jeon et al., 2007). Based on the findings of this study, future studies can explore how meeting physical activity guidelines, or how engaging MPA can be beneficial by using the JPHC cohort data, which will provide important information for public health.

The strengths of the present study were recruiting participants from four different locations, including both urban and rural areas. However, several limitations should be noted. First, the JPHC-PAQ did not consider sedentary behavior or LPA, of which recent studies have shown unique health benefits independent of MVPA (Owen et al., 2010; Amagasa et al., 2018), because these concepts were not sufficiently generalized at the time of developing the JPHC-PAQ. Second, using a 24 h-R as the gold standard criterion may suffer from recall bias. In addition, a 24 h-R logs one single activity for every 15-min, whereas accelerometers can record activities with high time resolution such as one-minute epoch (Ward et al., 2005). Thus, a 24 h-R measure may overlook estimating activities in short-bouts. Since recent advancement in accelerometry technology allows utilizing accelerometers for measuring physical activity (Lee and Shiroma, 2014), using accelerometers as a gold standard measure may be preferable. Third, the participants consisted largely of the working population with a narrow age-range,

Table 6
Validity and reliability of the JPHC-PAQ with 24-hour activity record by gender.

	Men				Women			
	Validity (Spearman's rho)	p	Reliabilit (Spearman's rho)	p	Validity (Spearman's rho)	p	Reliability (Spearman's rho)	p
Activity volume (MET-hours/day)								
Sleep	0.524	< 0.001	0.501	< 0.001	0.152	0.258	0.541	< 0.001
SB + LPA	0.565	< 0.001	0.635	< 0.001	0.335	0.011	0.664	< 0.001
MPA	0.383	0.005	0.653	< 0.001	0.248	0.063	0.224	0.100
VPA	−0.206	0.140	0.713	< 0.001	0.021	0.879	0.705	< 0.001
MVPA	0.721	< 0.001	0.768	< 0.001	0.404	0.002	0.433	0.010
Total PA	0.789	< 0.001	0.786	< 0.001	0.579	< 0.001	0.490	< 0.001
Activity time (hours/day)								
Sleep	0.520	< 0.001	0.521	< 0.001	0.170	0.206	0.557	< 0.001
SB + LPA	0.689	< 0.001	0.804	< 0.001	0.448	< 0.001	0.620	< 0.001
MPA	0.463	< 0.001	0.655	< 0.001	0.254	0.057	0.235	0.084
VPA	−0.204	0.144	0.713	< 0.001	0.021	0.877	0.705	< 0.001
MVPA	0.715	< 0.001	0.752	< 0.001	0.371	0.005	0.405	< 0.001

which may limit the generalizability of the results for the younger or non-working population. Fourth, this study could not consider possible seasonal effect on physical activity, especially in reliability assessment in test–retest (Tucker and Gilliland, 2007).

8. Conclusion

In addition to total PA, the JPHC-PAQ showed acceptable validity and reliability for intensity-specific physical activity, especially in estimating MVPA and MPA.

CRediT authorship contribution statement

Hiroyuki Kikuchi: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing. **Shigeru Inoue:** Conceptualization, Writing - original draft. **Yuko Odagiri:** Writing - review & editing. **Hikaru Ihira:** Writing - review & editing. **Manami Inoue:** Methodology, Writing - review & editing. **Norie Sawada:** Methodology, Writing - review & editing. **Mitsuhiko Noda:** Methodology, Writing - review & editing. **Shoichiro Tsugane:** Methodology, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2020.101169.

References

Ainsworth, B.E., Haskell, W.L., Whitt, M.C., et al., 2000. Compendium of physical activities: an update of activity codes and MET intensities. Med. Sci. Sport Exerc. 32 (9 Suppl), S498–504. http://www.ncbi.nlm.nih.gov/pubmed/10993420.

Albanes, D., Conway, J.M., Taylor, P.R., Moe, P.W., Judd, J., 1990. Validation and comparison of eight physical activity questionnaires. Epidemiology. https://doi.org/10.1097/00001648-199001000-00014.

Amagasa, S., Machida, M., Fukushima, N., et al., 2018. Is objectively measured light-intensity physical activity associated with health outcomes after adjustment for moderate-to-vigorous physical activity in adults? A systematic review. Int. J. Behav. Nutr. Phys. Act. https://doi.org/10.1186/s12966-018-0695-z.

Bouchard, C., Tremblay, A., Leblanc, C., Lortie, G., Savard, R., Thériault, G., 1983. A method to assess energy expenditure in children and adults. Am. J. Clin. Nutr. 37 (3), 461–467. https://doi.org/10.1093/ajcn/37.3.461.

Bull, F.C., Maslin, T.S., Armstrong, T., 2009. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. J. Phys. Act. Health. 6 (6), 790–804 http://www.ncbi.nlm.nih.gov/pubmed/20101923. Accessed November 6, 2018.

Craig, C.L., Marshall, A.L., Sjostrom, M., et al., 2003. International physical activity questionnaire: 12-country reliability and validity. Med. Sci. Sport Exerc. 35 (8),

1381–1395. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=12900694.

Dinger, M.K., Behrens, T.K., Han, J.L., 2006. Validity and reliability of the international physical activity questionnaire in college students. Am. J. Heal Educ. https://doi.org/10.1080/19325037.2006.10598924.

Fujii, H., Yamamoto, S., Takeda-Imai, F., et al., 2011. Validity and applicability of a simple questionnaire for the estimation of total and domain-specific physical activity. Diabetol Int. 2 (2), 47–54. https://doi.org/10.1007/s13340-011-0025-z.

Gebel, K., Ding, D., Chey, T., Stamatakis, E., Brown, W.J., Bauman, A.E., 2015. Effect of moderate to vigorous physical activity on all-cause mortality in middle-aged and older Australians. JAMA Intern. Med. 175 (6), 970–977. https://doi.org/10.1001/jamainternmed.2015.0541.

Haskell, W.L., Lee, I.M., Pate, R.R., et al., 2007. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Circulation 116 (9), 1081–1093. http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=17671237.

Hayasaka, S., Shibata, Y., Ishikawa, S., et al., 2009. Physical activity and all-cause mortality in Japan: The Jichi Medical School (JMS) cohort study. J. Epidemiol. 19 (1), 24–27. https://doi.org/10.2188/jea.JE20080043.

Ishikawa-Takata, K., Naito, Y., Tanaka, S., Ebine, N., Tabata, I., 2011. Use of doubly labeled water to validate a physical activity questionnaire developed for the Japanese population. J. Epidemiol. 21 (2), 114–121. https://doi.org/10.2188/jea.JE20100079.

Jeon, C.Y., Lokken, R.P., Hu, F.B., van Dam, R.M., 2007. Physical activity of moderate intensity and risk of type 2 diabetes. Diabetes Care 30 (3), 744–752. https://doi.org/10.2337/DC06-1842.

Kohl, H.W., Craig, C.L., Lambert, E.V., et al., 2012. The pandemic of physical inactivity: global action for public health. Lancet 380 (9838), 294–305. https://doi.org/10.1016/S0140-6736(12)60898-8.

Kriska, A.M., Pereira, M., Fitzgerald, S., Gregg, S., 1997. Modifiable activity questionnaire In: A collection of physial activity questionnaires for health-related research. Med. Sci. Sports Exerc. 29 (296), 73–78. https://doi.org/10.1007/978-1-4419-7826-4.

Kubota, Y., Iso, H., Yamagishi, K., Sawada, N., Tsugane, S., 2017. Daily Total Physical Activity and Incident Stroke. Stroke. https://doi.org/10.1161/STROKEAHA.117.017560.

Lee, P.H., Macfarlane, D.J., Lam, T.H., Stewart, S.M., 2011. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review. Int. J. Behav. Nutr. Phys. Act. https://doi.org/10.1186/1479-5868-8-115.

Lee, I.M., Shiroma, E.J., Lobelo, F., et al., 2012. Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy. Lancet 380 (9838), 219–229. https://doi.org/10.1016/S0140-6736(12)61031-9.

Lee, I.-M., Shiroma, E.J., 2014. Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. Br J Sport Med. 48 (3), 197–201. https://doi.org/10.1136/bjsports-2013-093154.

Meyer, A.M., Evenson, K.R., Morimoto, L., Siscovick, D., White, E., 2009. Test-retest reliability of the women's health initiative physical activity questionnaire. Med. Sci. Sports Exerc. https://doi.org/10.1249/MSS.0b013e31818ace55.

Miyachi, M., 2012. Measures of physical activity and exercise for health promotion by the Ministry of Health, Labour and Welfare. J. Phys. Fit Sport Med. 1 (3), 467–472. https://doi.org/10.7600/jpfsm.1.467.

Miyachi, M., Tripette, J., Kawakami, R., Murakami, H., 2015. "Plus10 min" of physical activity per day: Japan is looking for efficient but feasible recommendations for its population. J. Nutr. Sci. Vitaminol. (Tokyo). 61 (Supplement), S7–S9. https://doi.org/10.3177/jnsv.61.S7.

Naito Y. [Relationship between physical activity and health examination variables in male workers–new methods to assess physical activity and their applications to epidemiologic research]. Nihon Koshu Eisei Zasshi. 1994;41(8):706-719. http://www.ncbi.nlm.nih.gov/pubmed/7949282. Accessed November 8, 2018.

Owen, N., Healy, G.N., Matthews, C.E., Dunstan, D.W., 2010. Too much sitting: the population health science of sedentary behavior. Exerc. Sport Sci. Rev. 38 (3), 105–113. https://doi.org/10.1097/JES.0b013e3181e373a2.

Rafamantanantsoa, H.H., Ebine, N., Yoshioka, M., et al., 2002. Validation of three alternative methods to measure total energy expenditure against the doubly labeled water method for older Japanese men. J. Nutr. Sci. Vitaminol (Tokyo). https://doi.org/10.3177/jnsv.48.517.

Sasai, H., Nakata, Y., Murakami, H., et al., 2018. Simultaneous validation of seven physical activity questionnaires used in Japanese cohorts for estimating energy expenditure: A doubly labeled water study. J. Epidemiol. https://doi.org/10.2188/jea.JE20170129.

Tremblay, M.S., Aubert, S., Barnes, J.D., et al., 2017. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int. J. Behav. Nutr. Phys. Act. 14 (1), 75. https://doi.org/10.1186/s12966-017-0525-8.

Troiano, R.P., Berrigan, D., Dodd, K.W., Masse, L.C., Tilert, T., McDowell, M., 2008. Physical activity in the United States measured by accelerometer. Med. Sci. Sport Exerc. 40 (1), 181–188.

Tsugane, S., Sawada, N., 2014. The JPHC study: Design and some findings on the typical Japanese diet. Jpn. J. Clin. Oncol. 44 (9), 777–782. https://doi.org/10.1093/jjco/hyu096.

Tucker, P., Gilliland, J., 2007. The effect of season and weather on physical activity: A systematic review. Public Health. 121 (12), 909–922. https://doi.org/10.1016/j.puhe.2007.04.009.

Van, P.MNM., Chinapaw, M.J.M., Mokkink, L.B., et al., 2010. Physical activity questionnaires for adults A systematic review of measurement properties. Sport Med. https://doi.org/10.2165/11531930-000000000-00000.

Ward, D.S., Evenson, K.R., Vaughn, A., Rodgers, A.B., Troiano, R.P., 2005. Accelerometer use in physical activity: Best practices and research recommendations. Med. Sci. Sports Exerc. https://doi.org/10.1249/01.mss.0000185292.71933.91.

World Health Organization. Global recommendations on physical activity for health. 2010:7-8.