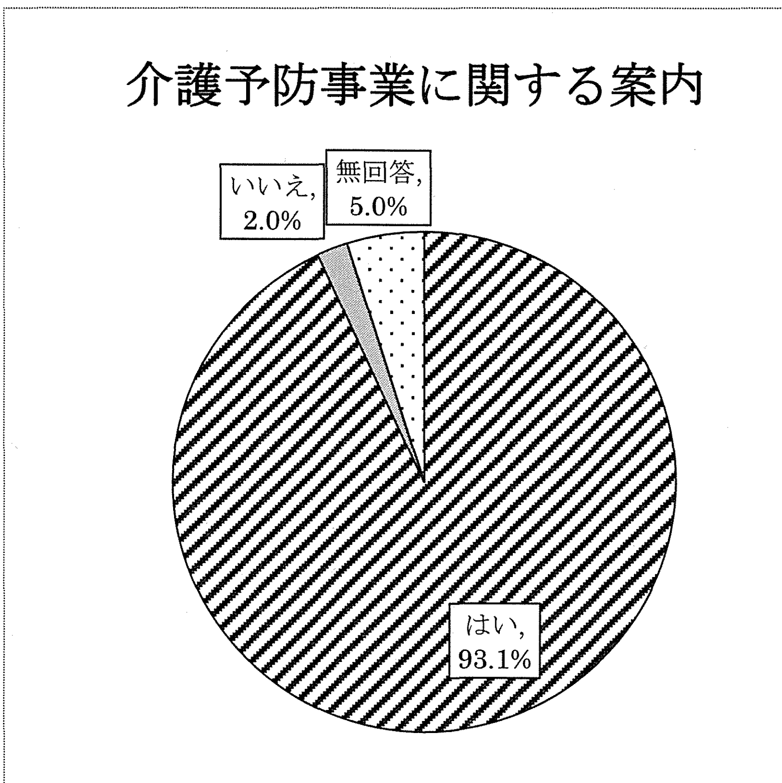
V．個人情報の使用について

①今後、区・研究所から介護予防事業に関するご案内をさせて頂いてもよろしいですか。

　　1．はい　　　　　2．いいえ



III. 学会等発表実績

学 会 等 発 表 実 績

委託業務題目「住民との協働による介護予防のまちづくりの効果検証のための地域コントロールトラ
機関名　地方独立行政法人東京都健康長寿医療センター

1．学会等における口頭・ポスター発表

発表した成果（発表題目、口頭・ポスター発表の別）	発表者氏名	発表した場所（学会等名）	発表した時期	国内・外の別
都市高齢者の不安に影響を与える要因（ポスター）	大渕修一，藤原佳典，河合恒，吉田英世，小島基永，平野浩彦，荒木厚，小山照幸，杉江正光，田中雅嗣	第49回日本理学療法学術集会	2014. 5. 30-6. 1	国内
要支援者の認定状況の悪化に関連する要因の分析（ポスター）	新井武志，大渕修一，河合恒	第49回日本理学療法学術大会	2014. 5. 30-6. 1	国内
サルコペニア危険度に対する自己評価法の開発　新考案『指輪っかテスト』の臨床的妥当性の検証	飯島勝矢，田中友規，石井伸弥，柴崎孝二，大渕修一，菊谷 武，平野浩彦，秋下雅弘，大内尉義	第56回日本老年医学会学術集会	2014. 6. 12-14	国内
日本人におけるサルコペニアおよび予備群の関連因子の同定　千葉県柏市における大規模健康調査から	飯島勝矢，田中友規，石井伸弥，柴崎孝二，大渕修一，菊谷 武，平野浩彦，秋下雅弘，大内尉義	第56回日本老年医学会学術集会	2014. 6. 12-14	国内
外来通院高齢者における心肺運動負荷試験を用いたサルコペニア診断の可能性	杉江正光，原田和昌，高橋哲也，小山照幸，大渕修一，金 憲経，許 俊鋭，井藤英喜	第56回日本老年医学会学術集会	2014. 6. 12-14	国内

高齢者のサルコペニアと心肺運動機能との関係	杉江正光, 原田和昌, 高橋哲也, 小山照幸, 大渕修一, 金 憲経, 許 俊鋭, 井藤英喜	第56回日本老年医学会学術集会	2014. 6. 12-14	国内
後期高齢期における膝伸展力の変化に関連する生活習慣の解明	小島成実, 金美芝, 吉田英世, 平野浩彦, 大渕修一, 島田裕之, 鈴木隆雄, 金憲経	第56回日本老年医学会学術集会	2014. 6. 12-14	国内
地域在住高齢者における骨粗鬆症（低骨量）が動脈硬化性疾患の発症に及ぼす影響	吉田英世, 金憲経, 吉田祐子, 小島成実, 金美芝, 清水容子, 平野浩彦, 鈴木隆雄	第16回日本骨粗鬆症学会	2014. 10. 23-25	国内
地域高齢者の脳神経由来栄養因子の血清濃度はうつ病発症後低下する（ポスター）	吉田英世, 井原一成, 島田裕之, 吉田祐子, 小島成実, 金美芝, 平野浩彦, 金憲経, 長谷川千絵, 飯田浩毅, 天野雄一, 端詰勝敬, 蜂須貢	第73回日本公衆衛生学会総会	2014. 11. 5-7	国内
Comparion of cognitive performance between community-dwelling elderly people who engage in social participating with and without-depression（口頭）	Ogawa S, Kawai H, Suzuki H, Yasunaga M, Takahashi T, Fukaya T, Yoshida H, Hirano H, Obuchi S, Fujiwara Y	The 10th IAGG (International Association of Gerontology and Geriatrics) Asia/Oceania Regional Congress	2015（予定）	国外
Relationship between sarcopenia and chewing ability in Japanese community-dwelling elderly（ポスター）	Murakami M, Hirano H, Watanabe Y, Sakai K, Kim H, Katakura A	AichiAAOM/EAOM Meeting in conjunction with the 6th World Workshop on Oral Medicine	April 9-12, 2014	国外

8020運動達成後の高齢者咀嚼機能低下のリスク因子としてサルコペニアの可能性（口頭）	平野浩彦，渡邊裕，小原由紀，枝広あや子，藤原佳典，河合恒，吉田英世，井原一成，大渕修一，金憲経	第36回日本老年医学会学術集会	2014.6.12-14	国内
日本人地域在住高齢者における咀嚼機能の低下がサルコペニアの重度化に及ぼす影響について（ポスター）	村上正治，平野浩彦，渡邊裕，枝広あや子	第25回日本老年歯科医学会学術大会	2014.6.13-14	国内
One-year change in Montreal Cognitive Assessment performance and related predictors in community-dwelling older men and women（ポスター）	Yoshinori Fujiwara, Hiroyuki Suzuki, Hisashi Kawai, Hirohiko Hirano, Hideyo Yoshida, Kazushige Ihara, Paulo H. M. Chaves Shuichi Obuchi	GSA’s 67th Annual Scientific Meeting	2014.11.5-9	国外
Cognitive characteristics of community-dwelling older people with mild cognitive impairment as assessed by the Japanese version of the Montreal cognitive assessment（ポスター）	Hiroyuki Suzuki, Yoshinori Fujiwara, Hisashi Kawai, Hirohiko Hirano, Hideyo Yoshida, Kazushige Ihara, Shuichi Obuchi	GSA’s 67th Annual Scientific Meeting	2014.11.5-9	国外

Can you ride a bicycle? The ability to ride a bicycle in elderly with mobility limitation influences social function（口頭）	Ryota Sakurai, Hisashi Kawai, Hideyo Yoshida, Taro Fukaya, Hiroyuki Suzuki, Hunkyung Kim, Hirohiko Hirano, Shuichi Obuchi, Yoshinori Fujiwara	第25回日本疫学会学術総会	2015	国内
認知機能低下が高齢者のソーシャルキャピタル劣化に及ぼす影響（口頭）	藤原佳典，鈴木 宏幸，河合 恒，安永正史，平野浩彦，吉田英世，小島基永，井原一成，大渕修一	第56回日本老年医学会学術集会	2014. 6. 12-14	国内
大腿前面筋エコー強度と1年後の運動器リスク出現との関係（ポスター）	河合恒，大渕修一，光武誠吾，吉田英世，平野浩彦，小島基永，藤原佳典，井原一成	第49回日本理学療法学術集会	2014. 5. 30-6. 1	国内

２．学会誌・雑誌等における論文掲載

掲載した論文（発表題目）	発表者氏名	発表した場所（学会誌・雑誌等名）	発表した時期	国内・外の別
Reference values and age and sex differences in physical performance measures for community-dwelling older Japanese: a pooled analysis of six cohort studies.	Seino S, Shinkai S, Fujiwara Y, Obuchi S, Yoshida H, Hirano H, Kim HK, Ishizaki T, Takahashi R; TMIG-LISA Research Group	PLoS One. 2014; 9(6): e99487.	2014	国外

Eating Alone as Social Disengagement is Strongly Associated With Depressive Symptoms in Japanese Community-Dwelling Older Adults.	Kuroda A, Tanaka T, Hirano H, Ohara Y, Kikutani T, Furuya H, Obuchi S, Kawai H, Ishii S, Akishita M, Tsuji T, Iijima K	J Am Med Dir Assoc. in press	2015	国外
Information processing speed and 8-year mortality among community-dwelling elderly Japanese.	Iwasa H, Kai I, Yoshida Y, Suzuki T, Kim H, Yoshida H	J Epidemiol. 24(1), 52-9	2014	国外
The combined status of physical performance and depressive symptoms is strongly associated with a history of falling in community-dwelling elderly: cross-sectional findings from the Obu Study of Health Promotion for the Elderly (OSHPE)	Makizako H, Shimada H, Doi T, Yoshida D, Tsutsumimoto K, Uemura K, Anan Y, Park H, Lee S, Ito T, Suzuki T	Archives of Gerontology and Geriatrics, 58: 327-331	2014	国外
Cognitive intervention through a training program for picture-book reading in community-dwelling older adults: a randomized controlled trial	Suzuki H, Kuraoka M, Yasunaga M, Nonaka K, Sakurai R, Takeuchi R, Murayama Y, Fujiwara Y	BMC Geriatrics, 14: 122	2014	国外

Engagement in paid work as a protective predictor of BADL disability in Japanese urban and rural community-dwelling elderly residents: An 8-year prospective study	Fujiwara Y, Shinkai S, Kobayashi E, Minami U, Suzuki H, Yoshida H, Ishizaki T, Kumagai S, Watanabe S, Furuna T, Suzuki T	Geriatrics Gerontology International, in press	2014	国外
Regional Cerebral Glucose Metabolism and Gait Speed in Healthy Community-Dwelling Older Women.	Sakurai R, Fujiwara Y, Yasunaga M, Takeuchi R, Murayama Y, Ohba H, Sakuma N, Suzuki H, Oda K, Sakata M, Toyohara J, Ishiwata K, Shinkai S & Ishii K.	J Gerontol A Biol Sci Med Sci., First published online July 14, 2014.	2014	国外
Influential factors affecting age-related self-overestimation of step-over ability. Focusing on frequency of going outdoors and executive function	Sakurai R, Fujiwara Y, Sakuma N, Suzuki H, Ishihara M, Higuchi T & Imanaka K.	Arch Gerontol Geriatr., 59(3), 577-583,	2014	国外
The effect of intergenerational programs on the mental health of elderly adults.	Murayama Y, Ohba H, Yasunaga M, Nonaka K, Takeuchi R, Nishi M, Sakuma N, Uchida H, Shinkai S & Fujiwara Y.	Aging & Mental Health, 18, 1-9	2014	国外

Dietary intake in Japanese patients with type 2 diabetes: Analysis from Japan Diabetes Complications Study.	Horikawa C, Yoshimura Y, Kamada C, Tanaka S, Tanaka S, Akane Takahashi A, Osamu Hanyu O, Araki A, Ito H, Tanaka A, Ohashi Y, Akanuma Y, Nobuhiro Yamada N, Sone H	J Diabetes Invest, 5:176-187	2014	国外
Beta Cell Telomere Attrition in Diabetes: Inverse Correlation Between HbA1c and Telomere Length.	Tamura Y, Izumiyama-Shimomura N, Kimbara Y, Nakamura KI, Ishikawa N, Aida J, Chiba Y, Mori S, Arai T, Aizawa T, Araki A, Takubo K, Ito H	J Clin Endocrinol Metab, 99:2771-2777	2014	国外
Dietary Sodium Intake and Incidence of Diabetes Complications in Japanese Patients with Type 2 Diabetes: Analysis of the Japan Diabetes Complications Study(JDCS).	Horikawa C, Yoshimura Y, Kamada C, Tanaka S, Tanaka S, Hanyu O, Araki A, Ito H, Tanaka A, Ohashi Y, Akanuma Y, Yamada N, Sone H; Japan Diabetes Complications Study Group	J Clin Endocrinol Metab, 99:3635-3643	2014	国外

Body mass index and mortality among Japanese patients with type 2 diabetes:Pooled analysis of the Japan Diabetes Complications Study and the Japanese Elderly Diabetes Intervention Trial.	Tanaka S, Tanaka S, Iimuro S, Akanuma Y, Ohashi Y, Yamada N, Araki A, Ito H, Sone H; for the Japan Diabetes Complications Study Groupthe Japanese ElderlyDiabetes Intervention Trial Group	J Clin Endocrinol Metab 2014 Sep 9:jc20141855.	2014	国外
Efficacy of HMG-CoA reductase inhibitors in the prevention cerebrovascular attack in 1016 patients older than 75years among 4014 type 2 diabetic individuals.	Hayashi T, Kubota K, Kawashima S, Sone H, Watanabe H, Ohrui T, Yokote K, Takemoto M, Araki A, Noda M, Noto H, Sakuma I, Yoshizumi M, Ina K, Nomura H; on behalf of Japan CDM group	Int J Cardiol. 2014 Nov 5;177(3):860-866	2014	国外
糖尿病患者と老年症候群. 高齢者の糖尿病	荒木厚	糖尿病, 57:676-678	2014	国内
高齢患者の栄養サポートに対する栄養評価の指標に「摂食意欲」を取り入れた試み.	府川則子, 砂川昌子, 金丸晶子, 藤冨篤子, 千葉優子, 金丸和富, 山口雅庸, 黒岩厚二郎, 井藤英喜, 荒木厚	静脈経腸栄養, 29 : 1363-1369	2014	国内

高齢患者専門の急性期病院におけるNST活動	府川則子, 荒木厚	日本臨床栄養学会雑誌, 36 : 206-209	2014	国内
高齢者の糖尿病治療 : J-EDIT(The Japanese Elderly Intervention Trial)研究の知見を踏まえて	荒木厚, 井藤英喜	日本老年医学会雑誌, 52 : 4-10	2015	国内
Relationship between chewing ability and sarcopenia in Japanese community-dwelling older adults.	Murakami M, Hirano H, Watanabe Y, Sakai K, Kim H, Katakura A	Geriatr Gerontol Int, Nov 3	2014	国外
Factors associated with self-rated oral health among community-dwelling older Japanese: A cross-sectional study	Ohara Y, Hirano H, Watanabe Y, Obuchi S, Yoshida H, Fujiwara Y, Ihara K, Kawai H, Mataki S	Geriatr Gerontol Int, Sep 20	2014	国外
地域在住高齢者における自転車関連事故発生率とその傷害率ー潜在的傷害事故の把握に向けた予備的検討	桜井良太, 河合 恒, 深谷太郎, 吉田英世, 金 憲経, 平野浩彦, 大渕修一, 藤原佳典	日本公衆衛生雑誌, 印刷中	2015	国内

One-year change in Montreal Cognitive Assessment performance and related predictors in community-dwelling older adults	Hiroyuki Suzuki, Hisashi Kawai, Hirohiko Hirano, Hideyo Yoshida, Kazushige Ihara, Hunkyung Kim, Paulo H. M. Chaves, Ushio Minami, Masashi Yasunaga, Shuichi Obuchi, Yoshinori Fujiwara	Journal of the American Geriatrics Society, in press.	2015	国外
大規模コホートデータによる地域高齢者の体力評価シートの作成	河合恒，清野諭，西真理子，谷口優，大渕修一，新開省二，吉田英世，藤原佳典，平野浩彦，金憲経，石崎達郎，高橋龍太郎，TMIG-LISA研究グループ	体力科学，64(2)，印刷中	2015	国内

Ⅳ. 研究成果の刊行物・別刷

Reference Values and Age and Sex Differences in Physical Performance Measures for Community-Dwelling Older Japanese: A Pooled Analysis of Six Cohort Studies

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Abstract

Objectives: To determine age- and sex-specific reference values for six physical performance measures, i.e. hand-grip strength, one-legged stance, and gait speed and step length at both usual and maximum paces, and to investigate age and sex differences in these measures among community-dwelling older Japanese adults.

Methods: We conducted a pooled analysis of data from six cohort studies collected between 2002 and 2011 as part of the Tokyo Metropolitan Institute of Gerontology-Longitudinal Interdisciplinary Study on Aging. The pooled analysis included cross-sectional data from 4683 nondisabled, community-dwelling adults aged 65 years or older (2168 men, 2515 women; mean age: 74.0 years in men and 73.9 years in women).

Results: Unweighted simple mean (standard deviation) hand-grip strength, one-legged stance, usual gait speed, usual gait step length, maximum gait speed, and maximum gait step length were 31.7 (6.7) kg, 39.3 (23.0) s, 1.29 (0.25) m/s, 67.7 (10.0) cm, 1.94 (0.38) m/s, and 82.3 (11.6) cm, respectively, in men and 20.4 (5.0) kg, 36.8 (23.4) s, 1.25 (0.27) m/s, 60.8 (10.0) cm, 1.73 (0.36) m/s, and 69.7 (10.8) cm, respectively, in women. All physical performance measures showed significant decreasing trends with advancing age in both sexes (all $P<0.001$ for trend). We also constructed age- and sex-specific appraisal standards according to quintiles. With increasing age, the sex difference in hand-grip strength decreased significantly ($P<0.001$ for age and sex interaction). In contrast, sex differences significantly increased in all other measures (all $P<0.05$ for interactions) except step length at maximum pace.

Conclusion: Our pooled analysis yielded inclusive age- and sex-specific reference values and appraisal standards for major physical performance measures in nondisabled, community-dwelling, older Japanese adults. The characteristics of age-related decline in physical performance measures differed between sexes.

Citation: Seino S, Shinkai S, Fujiwara Y, Obuchi S, Yoshida H, et al. (2014) Reference Values and Age and Sex Differences in Physical Performance Measures for Community-Dwelling Older Japanese: A Pooled Analysis of Six Cohort Studies. PLoS ONE 9(6): e99487. doi:10.1371/journal.pone.0099487

Editor: Ulrich Thiem, Marienhospital Herne - University of Bochum, Germany

Received December 20, 2013; **Accepted** May 15, 2014; **Published** June 12, 2014

Funding: This study was supported by grants from the Tokyo Metropolitan Government, the Japan Arteriosclerosis Prevention Fund (jals.gr.jp/en/index.html), the Research Institute of Science and Technology for Society, the Japan Science and Technology Agency (www.ristex.jp/EN/index.html), International Life Sciences Institute of Japan (www.ilsijapan.org/English/ILSIJapan/ILJ/IL.php), Grants-in-Aid for Scientific Research (B) (2) 14370150, (B) 17390194, (B) 21390212, and a Grant-in-Aid for Exploratory Research 17659192 from the Japan Society for the Promotion of Science, and Health Labour Sciences Research Grants H14-Chouju-006, H15-Ganyobo-065, H15-Seisaku-017, H16-Chouju-031, H23-Chouju-Ippan-001, and H23-Chouju-Ippan-002 from the Ministry of Health, Labour and Welfare of Japan. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

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¶ Membership of the TMIG-LISA (Tokyo Metropolitan Institute of Gerontology-Longitudinal Interdisciplinary Study on Aging) Research Group is provided in the Acknowledgments.

Introduction

Physical performance measures (PPMs) such as usual gait speed and hand-grip strength are indicators not only of physical function, but also current and future overall well-being, in older adults [1,2]. Recent systematic reviews and meta- and pooled analyses [3–6] showed that PPMs are effective at predicting adverse health outcomes, e.g. disability [7], institutionalization [8], hospitalization [9], and mortality [10]. A recent case-finding algorithm for sarcopenia [11] also included usual gait speed and hand-grip strength as appropriate screening tools. Thus, there is growing evidence of the importance of maintaining adequate physical performance in later life.

Some studies reported normative or reference values for PPMs [12–19]; however, no published study included age- and sex-specific reference values for multiple major PPMs among Asian adults or Japanese adults. Aoyagi et al. [20] conducted a cross-national comparison of PPMs in Japanese and American women and reported that gait speeds and chair stand times were faster for older Japanese women than for older American women, which suggests that traditional lifestyles may affect physical performance in later life. Because absolute levels of physical performance may vary between countries, it is difficult to extrapolate reference values from previous studies of Western populations [12–17,19] to older Japanese people. Furthermore, the measuring protocols used for several PPMs, especially gait speed and hand-grip strength, varied considerably between studies and countries, which makes comparison of values difficult [21–24]. Therefore, age- and sex-specific PPM reference values specifically for older Japanese adults should be established using unified measuring protocols.

Collaborative research and the combining of cohort data have recently increased in the area of ageing studies [25]. Although the use of a cross-study approach allows analyses to encompass many geographic areas and much larger samples, there may be problems due to differences between studies in the measurement of variables and the protocols used. However, the Tokyo Metropolitan Institute of Gerontology-Longitudinal Interdisciplinary Study on Aging (TMIG-LISA) Research Group [7,26–30] has regularly assessed one-legged stance with eyes open and usual and maximum gait step length, in addition to hand-grip strength and both usual and maximum gait speeds.

In the present study, we pooled cross-sectional data from cohort studies of the TMIG-LISA to establish reference values for six PPMs (hand-grip strength, one-legged stance with eyes open, and gait speed and step length at both usual and maximum paces), classified by age and sex. In addition, we investigated age and sex differences in these measures.

Methods

Data sources and study population

The data sources for this study were derived from the TMIG-LISA [7,26–30], which was established to determine risk factors for participants with geriatric diseases or chronic medical conditions and to identify factors that accelerate or decelerate aging in representative samples of older Japanese adults. In the present study, six TMIG cohort studies contributed data to a pooled analysis: the Nangai Cohort Study (NANGAI), Itabashi Cohort Study 2002 (ITABASHI02), Yoita Longitudinal Study (YOITA), Kusatsu Longitudinal Study (KUSATSU), Hatoyama Cohort Study (HATOYAMA), and Itabashi Cohort Study 2011 (ITABASHI11). We used baseline data or data from the year with the highest participation rate, all of which were collected between 2002 and 2011. The details of the study participants are discussed below (Figure 1).

Nangai Cohort Study (NANGAI). Nangai village is a mainly agricultural area in the northern Japanese prefecture of Akita [31]. The baseline survey was held from July through August 1992, and the participant selection process is described in more detail elsewhere [7,26,28,29]. In the present pooled analysis, we used surveillance data from 2002. The target population included 1327 residents (549 men, 778 women) aged 65 years or older. A total of 1068 ambulatory residents participated in the 2002 survey (446 men, participation rate of 81.2%; 622 women, participation rate of 79.9%; total participation rate of 80.5%).

Itabashi Cohort Study 2002 (ITABASHI02). For ITABASHI02, a baseline survey was conducted in Itabashi ward in north-west Tokyo, Japan in 2002. Two thousand residents (1000 men, 1000 women) aged 71 years or older living in 36 residential areas in Itabashi ward were randomly recruited. After excluding 55 people who were institutionalized, 1945 invitations for the comprehensive health checkups were sent out. Ultimately, 847 residents participated in the baseline survey (456 men, participation rate of 45.6%; 391 women, participation rate of 39.1%; total participation rate of 43.5%).

Yoita Longitudinal Study (YOITA). The Act on Assurance of Medical Care for Elderly People, which went into effect in Japan in 1983, requires all municipal governments in Japan to offer annual preventive health checkups to citizens aged 40 years or older. In conjunction with this service, we launched a longitudinal study on the aging and health of older adults living in Yoita town, a rural community in central Niigata Prefecture, Japan, in which older participants underwent an additional comprehensive geriatric assessment [32]. A total of 1380 residents (521 men, 859 women) aged 70 years or older were invited to participate in a baseline survey in 2004. Of those, 637 residents participated in the survey (261 men, participation rate of 50.1%; 376 women, participation rate of 43.8%; total participation rate of 46.2%).

Kusatsu Longitudinal Study (KUSATSU). We also conducted a longitudinal study in Kusatsu town, a rural community in north-west Gunma Prefecture, Japan, in 2002 [32]. We used data from health checkups conducted in 2008. The study targeted National Health Insurance subscribers aged 65–74 years and individuals 75 years or older in the Medical Insurance System for the Elderly Aged 75 or Over (966 men, 1219 women). Of that population, 665 residents participated in the 2008 survey (276 men, participation rate of 28.6%; 389 women, participation rate of 31.9%; total participation rate of 30.4%).

Hatoyama Cohort Study (HATOYAMA). The HATOYAMA study was a prospective cohort study of community-dwelling people aged 65 years or older living in the town of Hatoyama in Saitama Prefecture, Japan. The full details of the participant selection process were previously published [33]. Briefly, 2697 residents (1354 men, 1343 women) aged 65–84 years were selected using stratified sampling classified by age and residential area and random sampling strategies. Of those, 751 people participated in a baseline survey in 2010 (participation rate of 27.8%). Ultimately, 9 persons declined to participate in the study, and a total of 742 people were included in the study (428 men, participation rate of 31.6%; 314 women, participation rate of 23.4%; final participation rate of 27.5%).

Itabashi Cohort Study 2011 (ITABASHI11). In the ITABASHI11 study, 7162 residents aged 65–84 years living in nine residential areas surrounding the TMIG were recruited in 2011. After excluding 463 people who were institutionalized or overlapped from previous studies, 6699 invitations (3136 men, 3563 women) for the health checkups were sent out. In October 2011, 913 ambulatory residents received health checkups (participation rate of 13.6%) [30]. Of those, 905 residents agreed to participate in the study (361 men, participation rate of 11.5%; 544 women, participation rate of 15.3%; final participation rate of 13.5%).

Final sample size. Of all the participants (n = 4864) in the pooled data of the present study, individuals were excluded if they were not independent in any of five basic activities of daily living (ADLs), i.e. bathing, dressing, walking, eating, and continence [7] or had data missing for all PPMs. We also excluded four participants in the HATOYAMA study because their PPMs were measured at their homes. The final, pooled sample size was 4683 (2168 men and 2515 women; 28.8% and 28.7%, respectively, of the target population). All participants provided written informed consent, and all studies included in the pooled analysis were conducted with the approval of the institutional review board and ethics committee of the TMIG.

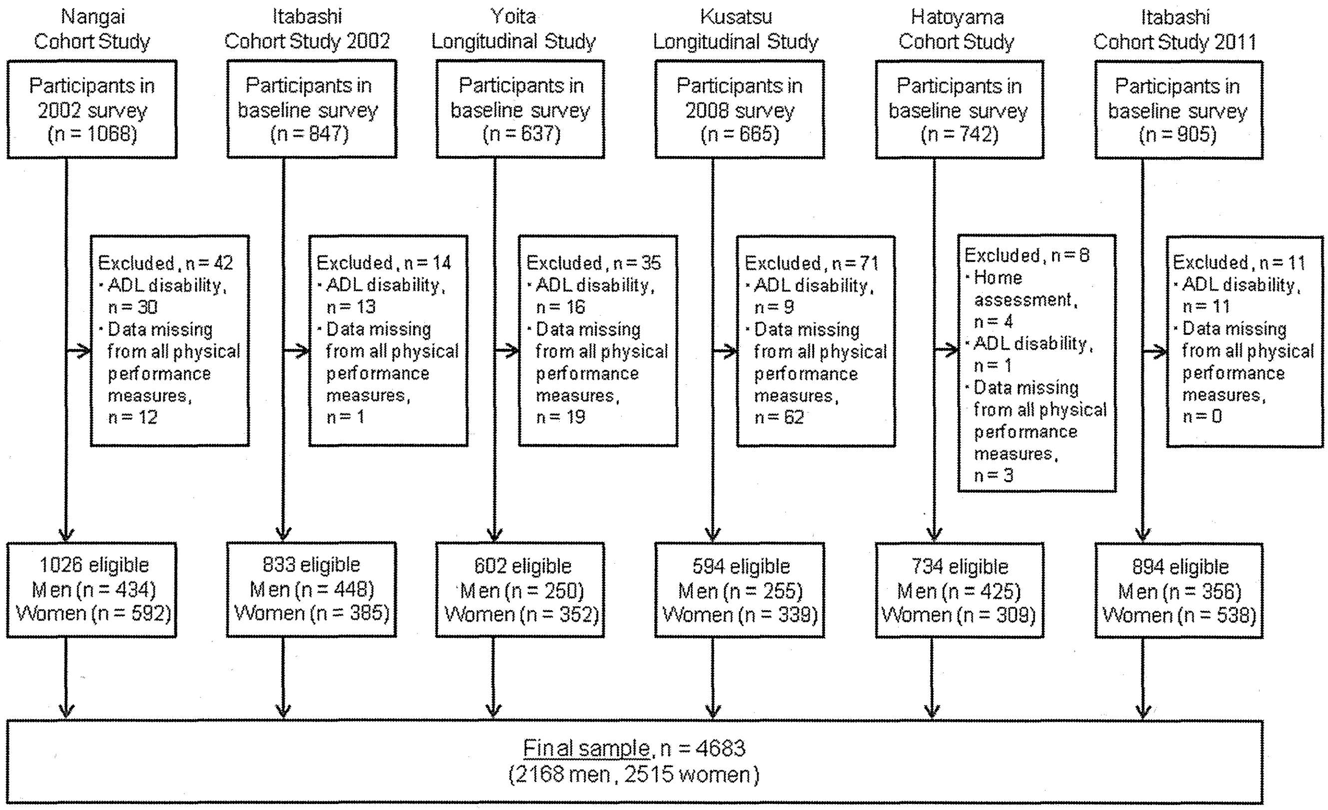

Figure 1. Schematic of participant selection processes in each included study.
doi:10.1371/journal.pone.0099487.g001

Assessment of health-related information

Age, body height and weight, history of chronic disease (hypertension, stroke, heart disease, and diabetes mellitus), self-rated health, alcohol drinking and smoking status, and Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC) [34] were assessed in all cohorts. Body mass index (BMI) was defined as body weight divided by the height squared (kg/m^2). History of chronic disease was determined through face-to-face interviews by physicians. Participants were asked whether a physician had diagnosed the specific condition (yes or no). Self-rated health (excellent, good, fair, or poor), alcohol drinking and smoking status (current, past, or never), and TMIG-IC were determined on the basis of questionnaire responses. The TMIG-IC was developed to assess levels of functional competence greater than those required for ADLs. The response to each item in this multidimensional 13-item index of competence is either 'yes' (able to perform) for 1 point or 'no' (unable to perform) for 0 points. The total score ranges from 0 to 13; lower scores indicate lower functional capacity [34].

Assessment of PPMs

Well-trained staff measured hand-grip strength, one-legged stance with eyes open, and gait speed and step length at both usual and maximum paces. Participants wore the same type of shoe that had been prepared for them during the initial assessment.

Hand-grip strength. Hand-grip strength was assessed in all cohorts using common Smedley-type hand dynamometers [7,29]. Participants stood with their arms hanging naturally at their sides holding the dynamometer with the grip size adjusted to a comfortable level. They were instructed and verbally encouraged to squeeze the hand-grip as hard as possible. In the YOITA, KUSATSU, and HATOYAMA studies, participants performed two trials with the dominant hand, and the best result (to the nearest 0.1 kg) was used. In all other cohorts, participants performed one trial with the dominant hand.

One-legged stance with eyes open. One-legged stance with eyes open was assessed using a participant's preferred leg in the NANGAI, KUSATSU, HATOYAMA, and ITABASHI11 studies. Participants were asked to place their hands at their waists while staring at a mark on the wall, raise one leg, and stand as long as possible. They were timed until they lost their balance or reached the maximum of 60 s [7]. Participants performed two trials, and the better time (to the nearest 0.1 s) was used.

Usual and maximum gait speeds. Usual and maximum gait speeds were measured over 5 m, with acceleration and deceleration phases of 3 m each, in all cohorts excepting ITABASHI11, in which participants were measured over a distance of 10 m, with acceleration and deceleration phases of 3 m each. Wang et al [35] reported that usual and maximum gait speeds measured over different distances are comparable only if acceleration and deceleration phases are used. We combined the 5 m and 10 m gait speeds because the acceleration and deceleration phases were identical for both measurement distances and because 3 m is considered sufficient to maintain steady usual and maximum gait speeds [35,36].

Participants stood with their feet behind but just touching a starting line marked with tape at 0 m. Upon receiving the tester's command, they started walking at their normal and maximum paces along an 11-m (16-m in the ITABASHI11) course. The actual walking time was measured over 5 m, starting with the body trunk past the 3-m mark and ending with the body trunk after the 8-m (13-m in the ITABASHI11) mark [7,29]. We calculated gait speed as distance divided by walking time (m/s). Usual gait speed was measured once. Maximum gait speed was measured twice, and the better of the two results (to the nearest 0.01 m/s) was used.

Usual and maximum gait step length. Step length is a component of gait speed and an independent predictor of cognitive decline [32]. Step length at both usual and maximum paces was assessed in the NANGAI, YOITA, KUSATSU, and HATOYAMA studies, in conjunction with usual and maximum gait speeds. Two other staff members measured mean step length by marking the heel points near the tape at 3 and 8 m and dividing the distance between the two heel points by the number of steps required [32]. Usual gait step length was measured once. Maximum gait step length was measured twice, and the better of the two results (to the nearest 0.1 cm) was used.

Statistical analyses

We used descriptive statistics to characterize the study population. Differences in characteristics between men and women were analyzed using the unpaired *t* test, chi-square test, and Mann-Whitney *U* test. The means and standard deviations (SDs) of all PPMs were tabulated per 5-year age group (65–69, 70–74, 75–79, 80–84, and 85 years or older) for each sex. We also calculated gait speed and step length at both usual and maximum paces normalized for height (computed as speed or length divided by height in meters) because height is a predictor of gait speed [12]. Similarly, we normalized hand-grip strength for weight (computed as strength in kg divided by weight in kg). Furthermore, we performed a random effects meta-analysis using a Microsoft Excel spreadsheet developed by Neyeloff et al. [37] to obtain weighted means of PPMs and tested heterogeneity across studies using Q and I^2 statistics [38].

To evaluate linear trends in the means of PPMs between the age groups, we used weighted one-way analyses of variance by sex. Furthermore, we visualized univariate regression lines between age and PPMs in both sexes. To examine whether sex differences in PPMs changed with age (due to statistical interactions between age and sex), we performed multiple linear regression analyses with six PPMs as dependent variables, and age, sex (men = 1, women = 2), and the age × sex product terms as independent variables. In these analyses, we used the mean deviations of the independent variables to avoid issues related to multicolinearity [39]. In addition, one-legged stance with eyes open was log transformed.

Quintiles of each physical performance measure were used to construct appraisal standards according to sex and age group. We used an alpha level of 0.05 to identify statistical significance and performed all statistical analyses using IBM SPSS Statistics Version 20.

Results

Table 1 shows the numbers of participants who provided complete data for each variable. Among the six PPMs, hand-grip strength and usual and maximum gait speed were assessed in all cohorts. The rates of missing data were 2.8% (n = 132) for hand-grip strength, 0.6% (n = 19) for one-legged stance with eyes open, 0.5% (n = 23) for usual gait speed, 0.7% (n = 22) for usual gait step length, 4.1% (n = 194) for maximum gait speed, and 3.9% (n = 111) for maximum gait step length. The lowest and highest rates of missing data were for usual and maximum gait speeds, respectively. The numbers of participants with complete data for each variable, by cohort, are available as (Table S1 in File S1).

Table 2 summarizes the characteristics of the study participants. There was no significant difference in age distribution between sexes. All PPM values were significantly higher in men than in women. The descriptive details of the study participants, by cohort (Tables S2 [men] and S3 [women] in File S1) and age group (Tables S4 [men] and S5 [women] in File S1), are available.

Tables 3 and 4 present unweighted simple means and SDs for PPMs according to age group in men and women, respectively. In both sexes, the sample size was small for the age group 85 years or older, and all PPMs showed significant decreasing trends with advancing age (all $P<0.001$ for trend). Unweighted simple means for PPMs according to age group were very similar to and only slightly lower than weighted means (Table S6 in File S1). The Q statistics for all age strata had probability levels exceeding 0.05 ($I^2 = 0.0$–29.2%), indicating that studies were homogeneous within strata.

Univariate linear regression analysis also showed significant associations between age and all PPMs in both sexes (all $P<0.001$; Figure 2). In multiple linear regression analyses, age and sex were significantly associated with hand-grip strength (standardized regression coefficient [β] = −0.30 and −0.70, respectively), one-legged stance with eyes open ($\beta = -0.39$ and −0.06, respectively), usual gait speed ($\beta = -0.40$ and −0.09, respectively) and step length ($\beta = -0.42$ and −0.31, respectively), and maximum gait speed ($\beta = -0.39$ and −0.27, respectively) and step length ($\beta = -0.38$ and −0.48, respectively) (all $P<0.001$). Age × sex interactions were small but significant in hand-grip strength ($\beta = 0.05$, $P<0.001$), one-legged stance with eyes open ($\beta = -0.08$, $P<0.001$), usual gait speed ($\beta = -0.08$, $P<0.001$) and step length ($\beta = -0.03$, $P = 0.030$), and maximum gait speed ($\beta = -0.04$, $P = 0.002$). However, the age × sex interaction was not significant for maximum gait step length ($\beta = -0.01$, $P = 0.527$). These associations and interactions remained significant after adjusting for chronic diseases, alcohol intake and smoking status.

Finally, Tables 5 and 6 show quintiles of PPMs according to age group in men and women, respectively. Although ceiling effects were seen in both sexes in the age group 65–74 years on the one-legged stance with eyes open test, all other PPMs had an approximately symmetrical distribution. The quintiles of weight-adjusted hand-grip strength and height-adjusted gait speed and step length at both usual and maximum paces are included as (Tables S7 [men] and S8 [women] in File S1).

Discussion

Main findings

Our pooled analysis established age- and sex-specific unweighted simple mean values for six PPMs among nondisabled, community-dwelling, older Japanese adults. Our study populations from six cohort studies were homogeneous. In addition, unweighted simple means for PPMs from a pooled analysis were very similar to weighted means from a random effects meta-analysis model, and their 95% confidence intervals largely overlapped. Therefore, we used unweighted simple means as the reference values and also constructed age- and sex-specific appraisal standards according to quintiles. These reference values and appraisal standards can be used in comparative assessments of healthy Japanese of the same sex and age group.

Sex difference in hand-grip strength significantly decreased with increasing age. In contrast, sex differences significantly increased for one-legged stance with eyes open, usual gait speed and step length, and maximum gait speed. These results suggest there are sex differences in the age-related decline of PPMs.

Comments on our results

Reference values. The present study is the first to report age- and sex-specific values for both gait speed and step length at

Table 1. Numbers of participants with complete data for each variable.

Variables	Sample with complete data, n		
	Overall	Men	Women
	(n = 4683)	(n = 2168)	(n = 2515)
Age	4683	2168	2515
Height	4680	2165	2515
Weight	4681	2166	2515
Body mass index	4680	2165	2515
Chronic disease			
Hypertension	4674	2164	2510
Stroke	4674	2164	2510
Heart disease	4659	2158	2501
Diabetes mellitus	4677	2164	2513
Self-rated health	4681	2166	2515
Alcohol drinking status	4679	2165	2514
Smoking status	4677	2164	2513
TMIG-IC	4682	2167	2515
Physical performance measures			
Hand-grip strength	4551	2097	2454
One-legged stance with eyes open	3229	1463	1766
Usual gait speed	4660[a]	2154[c]	2506[e]
Usual gait step length	2934	1352	1582
Maximum gait speed	4489[b]	2075[d]	2414[f]
Maximum gait step length	2845	1326	1519

TMIG-IC = Tokyo Metropolitan Institute of Gerontology Index of Competence.
[a]n = 3767 (5 m usual gait speed)+893 (10 m usual gait speed) = 4660.
[b]n = 3613 (5 m maximum gait speed)+876 (10 m maximum gait speed) = 4489.
[c]n = 1799 (5 m usual gait speed)+355 (10 m usual gait speed) = 2154.
[d]n = 1728 (5 m maximum gait speed)+347 (10 m maximum gait speed) = 2075.
[e]n = 1968 (5 m usual gait speed)+538 (10 m usual gait speed) = 2506.
[f]n = 1885 (5 m maximum gait speed)+529 (10 m maximum gait speed) = 2414.
doi:10.1371/journal.pone.0099487.t001

usual and maximum paces in older Japanese adults. Usual gait speed and hand-grip strength are the most commonly examined measures worldwide [5], and individual normative and reference data have been published, most commonly usual gait speed [12,16,17,19,40,41]. However, several studies [7,32,42,43] reported that maximum gait speed and step length at both usual and maximum paces were also valid for predicting adverse health outcomes. Shinkai et al. [7] reported that usual gait speed was more sensitive in predicting onset of ADL disability among people aged 75 years or older, whereas maximum gait speed was more sensitive among people aged 65–74 years. Fitzpatrick et al. [42] reported that maximum gait speed was most sensitive in predicting early cognitive decline in a healthy cohort. Furthermore, Taniguchi et al. [32] showed that usual gait step length in women and maximum gait step length in men were better than either usual or maximum gait speed at predicting future cognitive decline. These results indicate that measuring gait performance at both usual and maximum paces is important because the ability to voluntarily increase gait performance, i.e. gait speed and step length, may better reflect individual reserves in overall health status. Moreover, measuring gait parameters such as step length, cadence, and variability during maximum walking may optimize detection of early cognitive dysfunction among healthy older people [32,44]. Unfortunately, reference values for these measures were not previously available. This study is of great significance as it provides inclusive reference values for the PPMs considered to be the best indicators of overall well-being.

Compared with previous study results from Western populations [6,40,41,45], the mean values in the present study tend to be somewhat lower for hand-grip strength and higher in gait speed and step length. The measurement protocol for hand-grip strength recommended by The American Society of Hand Therapists (ASHT) [46] has been widely used in Western countries. That protocol calls for participants to be seated, shoulders adducted and neutrally rotated, elbow flexed at 90°, forearm in a neutral position, and the wrist between 0 and 30° of dorsiflexion. However, the protocol of standing with fully extended elbows has been used throughout Japan [7], and the standing protocol produced higher values than the ASHT recommended position [21]. Nevertheless, hand-grip strength was higher in older Westerners [45] than in the older Japanese included in the present study, which suggests that differences in body type (older Japanese are thinner and have less muscle mass than Westerners [47]) have a stronger effect than differences in measuring protocols.

Regarding the difference in gait performance between Western and Japanese adults, a component of the traditional Japanese lifestyle, i.e. lifelong squatting behaviors, may have a long-term

Table 2. Characteristics of the study participants (n = 4683).

Variables	Mean ± standard deviation or n (%)		*P* value
	Men (n = 2168)	Women (n = 2515)	
Age, years	74.0±5.3	73.9±5.5	0.800
Age group, n (%)			0.398
65–69	481(22.2)	588(23.4)	
70–74	727(33.5)	847(33.7)	
75–79	615(28.4)	658(26.2)	
80–84	297(13.7)	354(14.1)	
85 or over	48(2.2)	68(2.7)	
Geographic area, n (%)			<0.001
NANGAI	434(20.0)	592(23.5)	
ITABASHI02	448(20.7)	385(15.3)	
YOITA	250(11.5)	352(14.0)	
KUSATSU	255(11.8)	339(13.5)	
HATOYAMA	425(19.6)	309(12.3)	
ITABASHI11	356(16.4)	538(21.4)	
Height, cm	160.7±6.3	147.6±6.2	<0.001
Weight, kg	59.9±9.4	50.5±8.4	<0.001
Body mass index, kg/m^2	23.2±3.0	23.2±3.5	0.917
Chronic disease, n (%)			
Hypertension	981(45.3)	1216(48.4)	0.033
Stroke	179(8.3)	104(4.1)	<0.001
Heart disease	459(21.3)	420(16.8)	<0.001
Diabetes mellitus	300(13.9)	232(9.2)	<0.001
Self-rated health, n (%)			<0.001
Excellent to good	1777(82.0)	1997(79.4)	
Fair to poor	389(18.0)	518(20.6)	
Alcohol drinking status, n (%)			<0.001
Current	1426(65.9)	581(23.1)	
Past	245(11.3)	137(5.4)	
Never	494(22.8)	1796(71.4)	
Smoking status, n (%)			<0.001
Current	526(24.3)	107(4.3)	
Past	1048(48.4)	130(5.2)	
Never	590(27.3)	2276(90.6)	
TMIG-IC, score (0–13)	12.0±1.6	12.0±1.7	0.527
Instrumental self-maintenance (0–5)	4.8±0.6	4.9±0.6	0.002
Intellectual activity (0–4)	3.7±0.7	3.5±0.9	<0.001
Social role (0–4)	3.5±0.8	3.7±0.7	<0.001
Physical performance measures			
Hand-grip strength, kg	31.7±6.7	20.4±5.0	<0.001
One-legged stance with eyes open, s	39.3±23.0	36.8±23.4	0.003
Usual gait speed, m/s	1.29±0.25	1.25±0.27	<0.001
Usual gait step length, cm	67.7±10.0	60.8±10.0	<0.001
Maximum gait speed, m/s	1.94±0.38	1.73±0.36	<0.001
Maximum gait step length, cm	82.3±11.6	69.7±10.8	<0.001

NANGAI = Nangai Cohort Study; ITABASHI02 = Itabashi Cohort Study 2002; YOITA = Yoita Longitudinal Study; KUSATSU = Kusatsu Longitudinal Study; HATOYAMA = Hatoyama Cohort Study; ITABASHI11 = Itabashi Cohort Study 2011; TMIG-IC = Tokyo Metropolitan Institute of Gerontology Index of Competence.

doi:10.1371/journal.pone.0099487.t002

Table 3. Descriptive statistics for physical performance measures according to age group (men).

Variables	Mean ± standard deviation						P for trend
		Age group					
	Overall	65–69	70–74	75–79	80–84	85 or over	
Hand-grip strength, kg	31.7 ± 6.7	35.4 ± 5.8	32.7 ± 6.6	30.2 ± 6.1	27.7 ± 5.9	23.2 ± 5.3	<0.001
Weight-adjusted hand-grip strength, [strength (kg)/weight (kg)]	0.54 ± 0.11	0.58 ± 0.11	0.54 ± 0.11	0.52 ± 0.11	0.49 ± 0.11	0.45 ± 0.10	<0.001
(n)	(2097)	(473)	(699)	(597)	(281)	(47)	
One-legged stance with eyes open, s	39.3 ± 23.0	46.9 ± 20.6	41.7 ± 21.9	33.2 ± 22.9	26.0 ± 22.5	21.9 ± 23.5	<0.001
(n)	(1463)	(480)	(452)	(338)	(166)	(27)	
Usual gait speed, m/s	1.29 ± 0.25	1.39 ± 0.22	1.33 ± 0.23	1.26 ± 0.24	1.16 ± 0.25	1.11 ± 0.28	<0.001
Height-adjusted usual gait speed, [speed (m/s)/height (m)]	0.81 ± 0.16	0.86 ± 0.14	0.83 ± 0.14	0.79 ± 0.16	0.73 ± 0.16	0.72 ± 0.18	<0.001
(n)	(2154)	(479)	(722)	(612)	(293)	(48)	
Usual gait step length, cm	67.7 ± 10.0	71.4 ± 8.1	69.6 ± 9.2	65.4 ± 9.8	60.7 ± 9.9	57.3 ± 11.3	<0.001
Height-adjusted usual gait step length, [length (cm)/height (m)]	42.3 ± 5.9	44.1 ± 5.0	43.3 ± 5.4	41.3 ± 6.2	38.6 ± 6.1	37.2 ± 6.8	<0.001
(n)	(1352)	(389)	(444)	(322)	(149)	(48)	
Maximum gait speed, m/s	1.94 ± 0.38	2.09 ± 0.36	2.00 ± 0.36	1.87 ± 0.36	1.73 ± 0.37	1.65 ± 0.41	<0.001
Height-adjusted maximum gait speed, [speed (m/s)/height (m)]	1.21 ± 0.23	1.29 ± 0.22	1.24 ± 0.22	1.17 ± 0.22	1.09 ± 0.23	1.07 ± 0.26	<0.001
(n)	(2075)	(468)	(697)	(588)	(275)	(47)	
Maximum gait step length, cm	82.3 ± 11.6	86.8 ± 9.2	84.6 ± 10.6	79.2 ± 11.1	73.9 ± 12.0	70.7 ± 13.2	<0.001
Height-adjusted maximum gait step length, [length (cm)/height (m)]	51.4 ± 6.8	53.6 ± 5.5	52.7 ± 6.2	49.9 ± 6.8	46.9 ± 7.4	45.8 ± 8.0	<0.001
(n)	(1326)	(382)	(438)	(317)	(142)	(47)	

doi:10.1371/journal.pone.0099487.t003