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A Systematic Review of Validity and Reliability of Perceived Exertion Scales to Older Adults

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Abstract

Rating of perceived exertion (RPE) scales have been used to monitor and to prescribe exercise intensity of older adults, although many scales have not determined the validity and reliability to this population. The aim of this study was to evaluate the cross-cultural adaptation, validity and reliability of RPE scales applied to older adults. We performed the systematic search of the articles in March 2020 and included Web of Science, Scopus, PsycInfo, PubMed, Virtual Health Library and Science Direct databases. We limited the search to English language, with no year restriction. A modified McMaster (1998) critical appraisal tool determined the level of quality assessment in each included study. Forty-four papers met the inclusion criteria and there were 5 different RPE scales that had been used with older adults. Lower score in methodological quality was found to scale application (i.e., definition, instruction or familiarization) and there was no consensus about the instructions to use RPE scales. The Borg 6-20 was the more suitable tool for controlling exercise in older adults, due to its validation and cross-cultural adaptation for older adults. Thus, the results of this systematic review demonstrate the need for studies performing cross-cultural adaptation of other RPE scales to different languages and their validity and reliability under different exercise conditions when considering older adults' evaluations.

Key-words: elderly; exercise; perception; physical exertion; validation

Una revisión sistemática de la validez y confiabilidad de las escalas de esfuerzo percibido en adultos mayores

Resumen

Las escalas de calificación del esfuerzo percibido (RPE) se han utilizado para monitorizar y prescribir la intensidad del ejercicio de los adultos mayores, aunque muchas escalas no han determinado la validez y confiabilidad para esta población. El objetivo de este estudio fue evaluar la adaptación intercultural, la validez y la confiabilidad de las escalas de RPE aplicadas a adultos mayores. Realizamos una búsqueda sistemática de los artículos en marzo de 2020 e incluimos bases de datos de Web of Science, Scopus, PsycInfo, PubMed, Virtual Health Library y Science Direct. Limitamos la búsqueda al idioma inglés, sin restricción de año. Una herramienta de evaluación crítica modificada de McMaster (1998) determinó el nivel de evaluación de la calidad en cada estudio incluido. Cuarenta y cuatro artículos cumplieron con los criterios de inclusión, donde hubo 5 escalas de RPE diferentes utilizadas con adultos mayores. Se encontró una puntuación más baja en la calidad metodológica para escalar la aplicación (es decir, definición, instrucción o familiarización) y no hubo consenso sobre las instrucciones para usar escalas RPE. El Borg 6-20 fue la herramienta más adecuada para controlar el ejercicio en adultos mayores, debido a su validación y adaptación intercultural para adultos mayores. Por lo tanto, los resultados de esta revisión sistemática demuestran la necesidad de estudios que realicen la adaptación intercultural de otras escalas de RPE a diferentes idiomas, y su validez y confiabilidad bajo diferentes condiciones de ejercicio al considerar las evaluaciones de adultos mayores.

Palabras clave: mayor; ejercicio; percepción; esfuerzo físico; validación

Uma revisão sistemática da validade e reprodutibilidade das escalas de esforço percebido para idosos

Resumo

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Escalas de esforço percebido (PE) têm sido usadas para monitorar e prescrever a intensidade do exercício de idosos, entretanto muitas escalas não determinaram a validade e reprodutibilidade para essa população. O objetivo deste estudo foi avaliar a adaptação transcultural, validade e reprodutibilidade de escalas de PE aplicadas a idosos. Realizamos a busca sistemática dos artigos em março de 2020 e incluímos as bases de dados Web of Science, Scopus, PsycInfo, PubMed, Virtual Health Library e Science Direct. Limitamos a pesquisa ao idioma inglês, sem restrição de ano. Uma ferramenta de avaliação crítica modificada de McMaster (1998) determinou o nível de avaliação da qualidade em cada estudo incluído. Quarenta e quatro artigos preencheram os critérios de inclusão e 5 diferentes escalas de PE foram usadas com idosos. A pontuação mais baixa na qualidade metodológica foi encontrada para a aplicação da escala (ou seja, definição, instrução ou familiarização) e não houve consenso sobre as instruções de como usar as escalas de PE. A escala Borg 6-20 foi a ferramenta mais adequada para o controle do exercício em idosos, devido à sua validação e adaptação transcultural para idosos. Assim, os resultados desta revisão sistemática demonstram a necessidade de estudos que realizem a adaptação transcultural de outras escalas de PE para diferentes idiomas e sua validade e reprodutibilidade em diferentes condições de exercício ao considerar as avaliações de idosos.

Palavras-chave: idosos; exercício; percepção; esforço físico; validação

Introduction

Perceived exertion is defined as the subjectively perceived intensity of effort, strain, discomfort and/or fatigue felt during an exercise task (Noble and Robertson., 1996). Gunnar Borg developed the Rating of Perceived Exertion Scale (RPE - Borg, 1961) to male students (20-30 years), and after that he validated the scale to individuals aging from 18 to 79 years (Borg and Linderholm, 1967). Originally, RPE was created in association with heart rate (Borg, 1982) and this relationship has been observed with other physiological variables, e.g., oxygen consumption or respiratory rate (Chung, Zhao and Liu, 2015; Guidetti, Broccatelli, Baldari and Buzzachera, 2011). The use of RPE increased due to clinical and experimental interest in measuring perceived exertion during exercise (Colado et al., 2017; Souza et al., 2018). Thus, many numerical RPE scales have been developed to prescribe or to monitor exercise intensity (Borg, 1970; Gearhart, Lagally, Riechman and Andrews, 2008) due to its low cost and feasibility (Fragala-Pinkham, O'neil, Lennon, Forman and Trost, 2015; Robertson et al., 2002).

The benefits of physical activity on health status and daily living activities have increased the number of studies with older adults (Colado et al., 2017). Then, the use of RPE scale in such population has also increased, requiring the correct choice and use of the scale. The right choice is related to the scale being developed/adapted cross-culturally to older adults (Beaton, Bombardier, Guillemin and Ferraz, 2000), while the right use involves perceived exertion definition, instruction and familiarization with the scale (Pageaux, 2016). In addition, the validity of an RPE scale is mandatory to ensure the accuracy of perceived exertion reported by the individual, while the reliability is required to obtain a consistent measure of RPE in a period of time (Currell, and Jeukendrup, A, 2008).

Therefore, researchers evaluating RPE of older adults might consider the use of an RPE scale developed/adapted cross-culturally to the language and age of the participant, considering also validity and reliability of the measurements regarding to different exercise modes (e.g., resistance and cycling) and workload (i.e., continuous or intermittent). The aim of this systematic review was to evaluate the cross-cultural adaptation, validity and reliability of RPE scales used to older adults.

Methods

We conducted this review following the PRISMA guidelines (Moher, Liberati, Tetzlaff, Altman and Group, 2009). We performed the search of the articles in March 2020 and included PsycINFO, PubMed (MEDLINE), BVS (Virtual Health Library), Scopus, Web of Science and Science Direct databases. The search strategy included the subject headings 'perceived exertion' AND 'exercise' AND 'physical exertion' AND 'older adults OR aged OR elderly' in each database. The subjects "physical exertion", "aged" and "exercise" were Mesh words and "perceived exertion" was the most found term in this area. We limited the search to English language, with no publication year restriction.

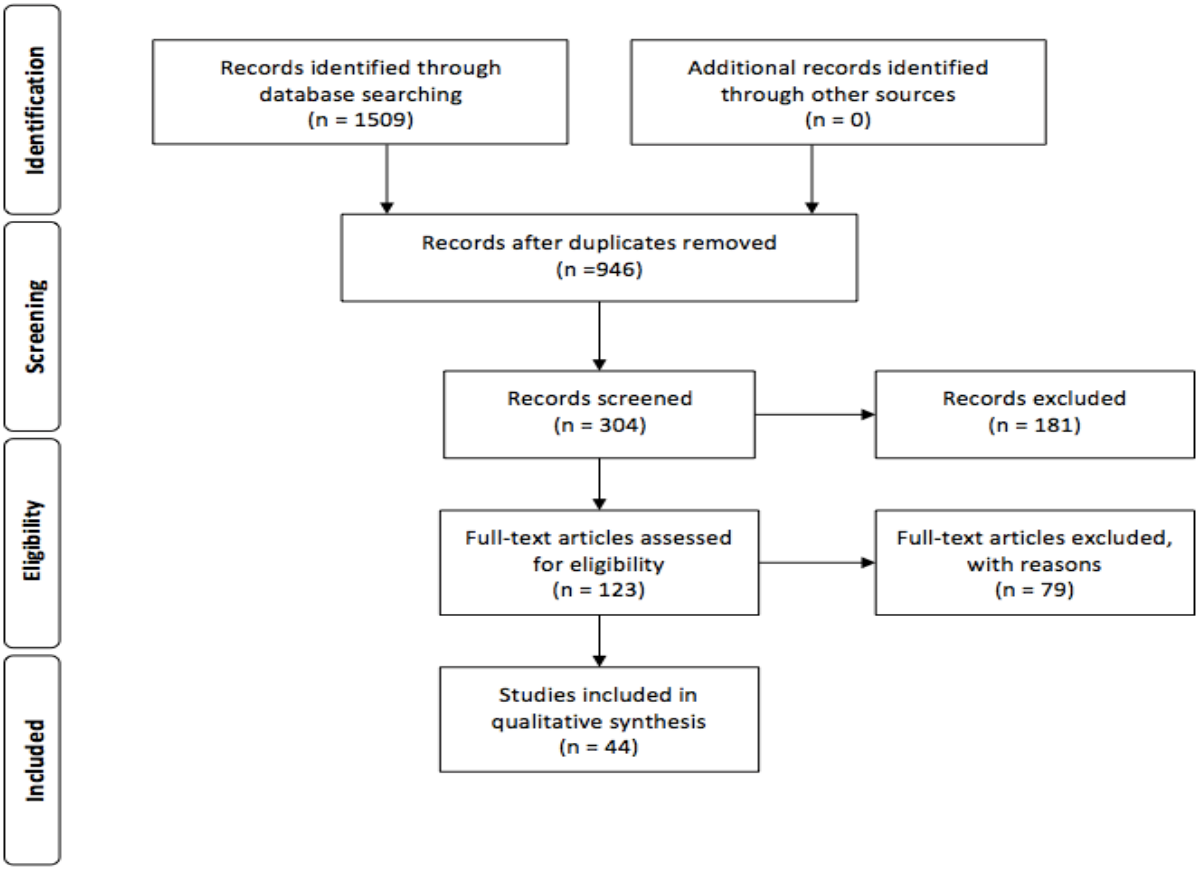
Studies investigating the RPE measured during physical activity in older adults, aged 60 years or older from community,

clinical and long-term care settings were considered. The sample size was not fixed in order to retrieve a large number of studies. We excluded review of literature, letter to the Editor, study without physical activity and/or not having RPE as a primary outcome. After selecting the articles through the titles, two independent investigators (PhD students) read the abstract and, following the inclusion/exclusion criteria, they selected the study to read the full version. When the two investigators had no consensus of an article inclusion, a third investigator undertook an independent review to determine the article suitability for inclusion.

Quality assessment considered the purpose clarity, conclusion appropriateness and a proper routine to evaluate the RPE through the scales. Two investigators evaluated independently the quality of studies using a modified guidelines version of the McMaster critical review form in quantitative studies (Law et al., 1998). One point was assigned when the item was accomplished, having 9 points to the highest methodological quality.

Results

The subject headings combination found 1509 studies, with 388 articles in PubMed, 387 in Science Direct, 90 in PsycINFO, 302 in Scopus, 28 in Web of Science and 311 in BVS databases. After removing duplicates, a total of 946 studies were available for screening (Figure 1). After screening titles, 304 potentially eligible studies were identified. After reading abstracts, 123 studies were fully read, and 44 studies were included in the review.



igure 1. Flow of information through the different phases of articles the search and selection of included in the systematic review.

Among the 44 articles analyzed, the highest score found was nine points observed in two articles and the lowest score was one point in one article. The RPE quality assessment criteria were based on the perceived exertion definition, instructions and familiarization with the scale. Fifty percent of the articles included the perceived exertion definition and 47% of the studies reported instructions. The lowest criterion of methodological quality was familiarization session that we observed in 29% of the studies (Table 1).

Table 1. Quality assessment of the studies included in the systematic review.

Author	Year	1	2	3	4	5	6	7	8	9	TOTAL
Barberan-Garcia et al.	2015		x	x	x	x				x	5
Buckley and Borg	2011	x	x	x	x		x	x	x	x	8
Buckley et al.	2009	x		x	x		x	x		x	6
Cabral et al.	2020	x	x	x	x	x	x	x	x	x	9
Chao et al.	2014	x	x	x	x	x	x		x		7
Chung et al.	2015	x		x	x	x					4
Colado et al.	2018	x	x	x	x		x	x	x	x	8
Colberg et al.	2003	x		x	x	x				x	5
Conlon et al.	2015	x	x	x	x					x	5
Desgorces et al.	2015	x	x	x	x		x	x		x	7
Donath et al.	2013		x	x	x					x	4
Dunbar and Kalinski	2004	x			x	x			x		4
Elhadi et al.,	2016	x	x	x				x		x	5
Eng et al.	2002	x		x	x						3
Fairman et al.,	2017	x	x	x	x	x	x	x		x	8
Follador et al.,	2019	x	x	x	x		x	x		x	7
Gearhart et al.	2011	x		x	x						3
Gearhart et al.	2009	x	x	x	x			x		x	6
Guidetti et al.	2011a	x		x	x	x	x		x		6
Guidetti et al.	2011b	x	x	x	x		x	x	x	x	8
Hu et al.	2007	x		x	x		x	x			5
Iellamo et al.	2014		x	x	x				x	x	5
Kakarot and Muller	2014		x	x	x		x			x	5
Lazzarini et al.	2017	x	x	x	x					x	5
Lins-Filho et al.	2019	x	x	x	x			x	x	x	7
Magal and Zoeller	2005	x		x	x						3
Milot et al	2019	x	x	x	x	x	x	x		x	7
Morrin et al	2018	x	x		x		x	x	x	x	7
Murrock	2002	x		x							2
Myers et al.	1987	x	x	x			x				4
Pinciviero	2011	x	x	x	x			x		x	6
Reychler et al.	2015	x	x	x	x	x				x	6
Row et al.	2012		x	x	x	x		x	x		6
Sage et al.	2013	x		x	x	x	x			x	6
Serafim et al.	2014	x		x	x	x	x	x		x	7
Shigematsu et al.	2004	x		x	x	x	x	x	x	x	8
Sidney and Shephard	1977	x									1

Souza et al.,	2018	x	x	x	x	x	x	x	x	x	9
Sumpter et al.	2015	x		x		x	x				4
Terziyski et al.	2010	x		x	x	x				x	5
White et al.	2017	x	x	x	x	x	x			x	7
Wong et al.	1990	x		x	x						3
Yu and Bil	2010	x	x	x	x	x	x	x		x	8
Yu et al.	2015	x	x	x	x	x		x		x	7

Note: 1=Study propose; 2=Experimental Design; 3=Statistical analysis; 4=Characteristics of the participants; 5=Country; 6=RPE Definition; 7=RPE Instruction; 8=RPE Familiarization; 9=Conclusion.

Borg 6-20 Scale

Twenty studies (45%) used Borg 6-20 Scale with participants from Brazil, USA, Canada, Spain, Japan and China countries. However, only three articles performed the cross-cultural adaptation to older adults, which were adapted to Japanese, to Cantonese and to Brazilian Portuguese languages.

Concurrent validity of Borg 6-20 Scale was determined in 50% of the articles, 10% determined predictive validity, 1% discriminant construct validity, 10% divergent construct validity and 40% of the studies did not check scale validity (Table 2). Concurrent validity was based on the relationship between Borg 6-20 Scale and Heart Rate (HR), Oxygen Uptake (VO_2), 1RM and functional tests (6-min and 12-min walking, 8-fit up and go test, 30-sec chair stand), commonly performed with incremental load (60% on cycle ergometer and treadmill), continuous load (20% on treadmill, functional test and arm curls) and intermittent load (one study on cycle ergometer). Predictive validity was developed in two studies with continuous load (resistance exercise and maximal repetition).

Divergent construct validity of the Borg 6-20 Scale was developed in one study with the CR-10 scale (continuous protocol in functional exercise), one study with instrumental and activities of daily living questionnaires (continuous protocol walking on treadmill and performing arm curls) and one study verified the discriminant construct validity comparing groups between young and older adults. Reliability was examined by test-retest method and it was found in 25% of the articles using intermittent, incremental and continuous load. In addition, healthy older adults participated in 65% studies, whereas three studies presented individuals with cardiac disease, one study diabetes disease, two studies stroke disease and one study idiopathic chronic fatigue.

Table 2. Characteristics of the studies that used Borg 6-20 Scale.

		Borg 6-20 Scale		
Author	Sample/Clinical condition	Protocol/Mode of Exercise	Country	Validity/Reliability/Cross-Cultural Adaptation
Buckley and Borg 2011	13 active women and 13 active men	Incremental/ RE		
Buckley et al. 2009	11 men/women/Cardiac	Incremental/Treadmill		Test-Retest Reliability/ICC=.85
Cabral et al. 2020	14 women	Incremental/Treadmill	Brazil	Cross-cultural adaptation Concurrent validity/ HR r=.57-.84; VO_2 r= .47-.82 Discriminant construct validity r=.50 Test-Retest Reliability/ICC=.95

Chung et al. 2015	40 men/women	Intermittent/CE	China	Cross-cultural adaptation Concurrent validity/ HR, *r*=.70;VO_2, *r*=.51 Test-Retest Reliability/ICC=.79
Colberg et al. 2003	13 men/women/Diabets	Incremental/CE	USA	Concurrent validity/ %VO_2R, *r*=.94; *r*=7.14
Dunbar and Kalinski 2004	6 women	Incremental/CE	USA	
Eng et al. 2002	25 men/women/Stroke	Continuous/12 min, 6 min, self-paced walking		Concurrent validity/ 6min, *r*=-.10; 12min, *r*=-.06
Hu et al. 2007	193 men/women	Incremental/Treadmill		
Lazzarini et al. 2017	20 men/women	Continuous/RM		Predictive validity/ 1RM, R^2=.976; Test-Retest Reliability/ICC=.78
Magal and Zoeller 2005	6 patients/ Cardiopulmonary	Incremental/CE		
Milot et al., 2019	12 Older adults with 1 Stroke	Incremental/ Functional and strength training	Canada	
Myers et al. 1987	9 men/Chronic atrial fibrillation	Incremental/Treadmill		Concurrent validity/ VO_2, *r*=.81–.88; HR, *r*=.31–.45
Row et al. 2012	21 men/women	Continuous/RE	USA	Predictive validity/ %1RM, R^2=99.5; Test-Retest Reliability/ICC=.73
Serafim et al. 2014	10 women	Incremental/Treadmill	Brazil	Concurrent validity/ HR *r*=.39–.41; VO_2 *r*=.22–.32
Shigematsu et al. 2004	29 women	Incremental/CE	Japan	Cross-cultural adaptation and Concurrent validity/VO2; HR *r*=.78–0.99
Sidney and Shephard 1977	56 men/women	Incremental/CE		
Souza et al., 2018	35 women	Continuous/ treadmill and arm curls	Brazil	Concurrent validity/ 6 min walking test; 30s chair stand *r*=.47-.59/ Divergent Construct Validity between Borg 6-20 and ADL and IADL questionnaires *r*=.96-.99 Test-retest reliability/ICC=.96 - .99
Sumpter et al. 2015	14 men/women	Continuous/ Functional	Spain	Concurrent validity/ 8-ft-up-and-go Test, *r*=-.862 Divergent Construct Validity/ Borg 6-20 between VAS and SF-26, *r*=.95

Valiani et al. 2016	25 men/women and 20 patients/Idiopathic chronic fatigue	Incremental/400-m walk		
Yu and Bil 2010	4 men	Incremental/CE	USA	Concurrent Validity/ HR, *r*=.38

Note: HR, Heart rate; %1RM, percentage of one maximum repetition; 6min, 6 minutes' walk test; 12min, 12 minutes' walk test; VO_2, Oxygen uptake; $\%VO_2$, Percentage of oxygen uptake. USA, United States of America; CE, Cycle ergometer; RE, Resistance exercise; IADL, instrumental activities of daily living; ADL, activities of daily living; VAS, visual analogue scale; SF-36, Short Form Health Survey; R^2, related to predictive validity.

CR-10 Scale

Twenty studies (45%) used CR-10 Scale with participants from Brazil, USA, Canada, Spain and Belgium countries. However, there were no articles performing the cross-cultural adaptation to older adults. Concurrent validity was performed in 25% of the articles, one study predictive validity, one study divergent construct validity and 65% did not examine scale validity (Table 3). Concurrent validity was based on the relationship between CR-10 Scale and HR, fatigue, RPE session and functional tests (30-sec chair stand), commonly performed with continuous (80%, cycle ergometer, rowing, resistance exercise, treadmill and functional) and intermittent load (one study on treadmill). Predictive validity was developed in one study with continuous load (maximal repetition). Divergent construct validity was developed in one study with 30-second chair stand test (continuous protocol in functional exercise). Reliability was performed in one study. Healthy older adults participated in 70% of studies, whereas 15% presented chronic obstructive pulmonary disease, one androgen deprivation therapy, one post-infarction heart failure, one hypertensive, one stroke disease, one chronic heart failure disease, and one Alzheimer.

Table 3. Characteristics of the studies that used OMNI-res (resistance exercise) and OMNI-cycle (cycling exercise) scales.

OMNI-res					
Author	Sample/Clinical condition	RPE Scale	Protocol/Mode of Exercise	Country	Validity/Reliability/Cross-Cultural Adaptation
Colado et al. 2018	26 men/women	OMNI-res	Continuous/RE		Concurrent validity/HR and Applied force Test-retest Reliability/ICC=.69–.80
Conlon et al. 2015	41 men/women	OMNI-res	Continuous/RM		
Gearhart et al. 2011	49 men/women	OMNI-res	Continuous/RM		
Gearhart et al. 2009	49 men/women	OMNI-res	Continuous/RM		
OMNI-cycle					

Guidetti et al. 2011a	82 men/women	OMNI-cycle Italian	Incremental/CE	Italy	Cross-cultural adaptation and Concurrent validity/ HR, men/women *r*=.73/.73; VO_2, *r*=.69/.63; Pulmonary ventilation, *r*=.74/.71; Respiratory rate, *r*=.64/.56
Guidetti et al. 2011b	76 men/women	OMNI-cycle	Incremental/CE		Concurrent validity/ men/women, HR, *r*=.91/.91; VO_2, *r*=.89/.89; $\%VO_{2Peak}$, *r*=.92/.90; VE, *r*=.89/.91; RR, *r*=.82/.81; RER, *r*=.85/.87 Divergent Construct Validity between OMNI-cycle and Borg 6-20, *r*=.97- .96

Note: RPE, Rating of perceived exertion; HR, Heart rate; VO_2, Oxygen uptake; $\%VO_{2peak}$, percentage of peak of oxygen uptake; RER, Respiratory-exchange ratio; RR, Respiratory rate; CE, Cycle ergometer; RE, Resistance exercise; PV, Pulmonary ventilation; RM, maximum repetition.

OMNI Scales

OMNI, which is a contraction of the word omnibus suggesting applicability of the metric to a wide range of individuals and physical activity settings, has been presented in two different types, OMNI-res (used for resistance training) and OMNI-cycle (used for cycling ergometer) (Robertson et al., 2005). The OMNI-res was used in four studies, while the OMNI-cycle was used in twTo studies (Table 4). Only one article employed a cross-cultural adaptation to older adults, in which OMNI-cycle was adapted to Italian language. Examined the concurrent validity 50% of the articles, and one study divergent construct validity. Concurrent validity was based on the relationship between OMNI Scales and HR, VO2, Ventilation (VE), Respiratory Rate (RR), Respiratory-exchange ratio (RER) and applied force, commonly performed with incremental (two studies using cycle ergometer) and continuous load (one study with resistance exercise). Divergent construct validity was developed in one study with Borg 6-20 scale (incremental load in cycle ergometer). Reliability was examined by test-retest method and we found in one article using continuous load in resistance exercise. Only healthy older adults participated in the studies with OMNI Scales.

Table 4. Characteristics of the studies that used CR-10 scale.

		CR-10		
Author	Sample/Clinical condition	Protocol/Mode of Exercise	Country	Validity/Reliability/Cross-Cultural Adaptation
Barberan-Garcia et al. 2015	15 men/women/COP	Continuous/6-min and back-and-forth test	Spain	
Buckley and Borg 2011	13 active women and 13 active men	Incremental/Strength training		
Chao et al. 2014	16 women	Continuous/Tai Chi Chuan	Brazil	

Desgorces et al. 2015	18 men	Continuous/RM		Predictive Validity/ %1RM pre-training, R^2=.59; post-training, R^2=.83
Donath et al. 2013	20 men/women	Incremental/Treadmill		
Elhadi et al., 2016	16 men and 8 women	Continuous/ Treadmill		
Fairman et al., 2017	77 men in Androgen deprivation therapy	Incremental/ Upper and lower body strength RM	USA	
Follador et al., 2019	70 women	Continuous/ Tai chi, yoga, stretching		
Iellamo et al. 2014	20 men/Post-infarction heart failure	Intermittent/Treadmill		Concurrent validity/ HR and RPE-session, *r*=.72
Lins-Filho et al. 2019	20 women	Continuous/Treadmill		Reliability/ICC=.80
Morrin et al. 2018	9 women and 5 men pre-hypertensive and stage 1 hypertensive	Intermittent/ Hand-grip dynamometer		
Murrock et al. 2002	30 men/women	Continuous/CE, Treadmill, Step and Arm CE		
Pincivier o et al. 2011	15 men	Continuous/MVC		
Reychler et al. 2015	41 men/women/COP	Continuous/CE, Rowing, RE and Treadmill	Belgiu m	Concurrent validity/ Fatigue (with music), *r*=.55; Fatigue (without music), *r*=.42
Sage et al. 2013	37 men/women/Stroke	Incremental/CE	Canada	
Sumpter et al. 2015	14 men/women	Continuous/ Functional	Spain	Concurrent validity/30-s Chair Stand Test, *r*=-.95; Divergent Construct validity CR-10 between VAS and SF-26 *r*=.88

Terziyski et al. 2010	17 patients/Chronic heart failure disease and 16 patients/COP and 16 controls	Continuous/CE	USA	
White et al. 2017	10 men/women	Continuous/MVC	USA	
Wong et al. 1990	138 men/women	Continuous/Treadmill		Concurrent validity/HR, VO_2,VE
Yu et al. 2015	8 men/women/Alzheimer	Continuous/CE	USA	Concurrent validity/ HR, *r*=-.11- .31

Note: RPE, Rating of perceived exertion; HR, Heart rate; %1RM, percentage of one maximum repetition; VO_2, Oxygen uptake; USA, United States of America; COP, Chronic obstructive pulmonary; MVC, Maximum voluntary contractions; CE, Cycle ergometer; RE, Resistance exercise; VE, minute ventilation; VAS, visual analogue scale; SF-36, Short Form Health Survey, R^2, related to predictive validity.

RPE-color and Category Partitioning scales

Two studies used the RPE-color and Category Partitioning (CP) Scale (Table 5). The RPE-color Scale was used with healthy older adult participants from Brazil, in which the concurrent validity was determined based on the relationship with HR and VO_2, performed with incremental load on treadmill. Divergent construct validity was performed with Borg 6-20 scale. The CP Scale was used with healthy older adult participants, and the concurrent and predictive validity were based on the relationship with HR during incremental cycling exercise.

Table 5. Characteristics of the studies that used Category Partitioning and RPE-color scales.

Author	Sample/Clinical condition	Scale	Protocol/Mode of Exercise	Country	Validity/Reliability/Cross-Cultural Adaptation
Kakarot and Muller 2014	10 men	Category Partitioning (CP)	Incremental/CE		Concurrent and predictive validity/ HR, *r*=.95; Intensity, *r*=.96; R^2=.69
Serafim et al. 2014	10 women	RPE-color	Incremental/Treadmill	Brazil	Concurrent validity/ HR, *r*=.39–.41; VO_2, *r*=.22–.32 Divergent Construct Validity between RPE-color and Borg 6-20 Scale

Note: RPE, Rating of perceived exertion; HR, Heart rate; CE, Cycle ergometer; VO_2, Oxygen uptake, R^2, related to predictive validity.

Discussion

The aim of this systematic review was to evaluate the cross-cultural adaptation, validity and reliability of RPE scales applied to older adults. We found that several studies did not report the scale language used to a specific participant's nationality and few studies developed a properly cross-cultural adaptation for RPE Scales. Besides, the absence of the perceived exertion information (i.e., definition, instruction or familiarization) could affect the validation process. Furthermore, we found five different scales in the present review; however, the Borg 6-20 scale was the most cross-culturally adapted, validated and reliable for older adults.

Methodological quality

Among the articles included in this systematic review, we observed discrepancies in the quality assessment of RPE scales, more specifically in 3 out of 9 criteria. Only 16% of the articles reached these 3 criteria (i.e., definition of perceived exertion, instructions and familiarization). Separately, perceived exertion definition and instructions to use RPE scale were observed in 50 and 47% of the articles, respectively. The correct information of the definition and instructions surely help participants to provide their perceived exertion accurately, aiming to increase the quality of RPE-related criteria (Pageaux, 2016). The absence of a unique perceived exertion definition (Pereira, de Souza, Reichert and Smirmaul, 2014) can bias the validity of RPE scales, thereby generating inconsistent results among studies. The familiarization was the lowest criterion reached between the articles included in this systematic review. A proper familiarization with the RPE scale is required, helping participants to not underestimate or overestimate their RPE (Pageaux, 2016). Previous study showed that one session is able to stabilize the RPE measure in older adults (Souza et al., 2018). Therefore, we concluded that the incongruence among the results of many researches may be due to a non-standardization of RPE scale application, related to a lack of perceived exertion definition, a poor instruction and the absence of a familiarization session.

Cross-cultural adaptation

In the present systematic review, Borg 6-20 scale was cross-culturally adapted to Japanese, Cantonese and Brazilian Portuguese languages, and OMNI-cycle was cross-culturally adapted to Italian language. Despite the CR-10 was the second scale more used among the studies with participants from many different nationalities, the studies have not performed the cross-cultural adaptation process. We found in the literature that cross-cultural adaptation preserves the validity of self-reported tools (Beaton et al., 2000). This process ensures that verbal portion of the scale retains accurate description of the perceived exertion construct, thereby older adults could understand RPE correctly. Little is known if the translation of verbal descriptors from English to another language would elicit similar perceptual responses and this issue could influence on the validity of RPE (Guidetti et al., 2011). Furthermore, changes to the qualitative semantics in the original scale can occur when cross-cultural adaptation is not applied. Therefore, the lack of a proper cross-cultural adaptation process could directly influence the values reported when the translated scale is used (Cabral, Lopes, Wolf, Stefanello and Pereira, 2017).

Validity and Reliability

The validity and reliability process were poorly reported among the studies. We observed four types of validity, *i.e.*, concurrent, discriminant construct, divergent and predictive validity. There is no consensus in the literature which type of validity is fundamental to check psychometric of a scale, but concurrent validity is the most applied because it helps to replace expensive and/or invasive measures for simpler tools, such as the RPE scales (Streiner, Norman and Cairney, 2015). That explains why the common validity type reported in the studies was the concurrent, having HR as a criterion measure. Moreover, concurrent validity is easier to apply once the criterion validity is the physiological measure that has already been validated to evaluate the exercise intensity (Chen, Fan and Moe, 2002). Besides, the main reason of the HR has been used in a large number of concurrent validity studies is because the first RPE scale (*i.e.*, Borg 6-20) had been developed using the HR as criterion validity measure (Borg, 1982).

Divergent validity was the second most frequently used type of validity among the articles, using Borg 6-20 Scale as the criterion instrument. The Borg 6-20 was the pioneer scale and its use has already been consolidated in the literature (Chung et al., 2015; Eng, Chu, Dawson, Kim and Hepburn, 2002; Milot, Léonard, Corriveau and Desrosiers, 2019; Myers et al., 1987). However, it is important to select in divergent validity a criterion instrument adapted to the participant's language, since different RPE scales have been developed (Barberan-garcia et al., 2015; Guidetti et al., 2011; Kakarot and Müller, 2014). When this criterion is established correctly, there is higher accuracy in the RPE reported by the participant, and RPE scale validity can be confirmed.

We observed the reliability process in a few articles among the RPE scales, in which only Borg 6-20 Scale, CR-10 and OMNI-res checked this psychometric property. Therefore, it was not possible to confirm if the other RPE Scales (*i.e.*, OMNI-cycle, CP and RPE-color scales) have generated consistent results for older adults, once it was not reported the reliability.

If reliability is not checked, older adults' perception of effort may change in a period of time and this would affect temporal consistency of RPE. Thus, reliability is required to confirm the temporal stability of RPE measure (Currell, and Jeukendrup, 2008).

Conclusion and practical application

The present study showed that Borg 6-20 Scale was the scale that presented more cross-cultural adaptation, validity and reliability for older adults than other RPE scales. Thus, studies performing cross-cultural adaptation of other RPE scales to different languages and their validity and reliability under different exercise conditions are required, when considering older adults' evaluations. As a practical application, future research should use this systematic review before evaluating RPE of older adults, in order to determine which scale to use considering participants' language and clinical condition, exercise mode and protocol.

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References

Barberan-garcia, A., Arbillaga-etxarri, A., Gimeno-santos, E., Rodríguez, D. A., Torralba, Y., Roca, J. and Vilaró, J. (2015). Nordic Walking Enhances Oxygen Uptake without Increasing the Rate of Perceived Exertion in Patients. *Respiration*, *89*, 221–225. https://doi.org/10.1159/000371356

Beaton, D. E., Bombardier, C., Guillemin, F. and Ferraz, M. B. (2000). Guidelines for the process of cross-cultural adaptation of self-report measures. *Spine*, *25*(24), 3186–3191. https://doi.org/10.1097/00007632-200012150-00014

Borg, G and Linderholm, H. (1967). Perceived exertion and pulse rate during graded exercise in various age groups. *Acta Medica Scandinavica*, *181*, 194–206.

Borg, G. (1961). Perceived exertion in relation to physical work load and pulse rate. *Forhandlingar, Kunglia Fysiografiska Sallskapets i Lund*, *31*, 105–115.

Borg, G. (1970). Perceived exertion as an indicator of somatic stress. *Scand J Rehab Med*, *2–3*, 92–98.

Borg, G. (1982). Psychophysical bases of perceived exertion. Med Sci Sports Exerc., 14, 377–381. doi:10.1249/00005768-198205000-00012

Buckley, J. P., Sim, J. and Eston, R. G. (2009). Reproducibility of ratings of perceived exertion soon after myocardial infarction : responses in the stress- testing clinic and the rehabilitation gymnasium. *Ergonomics*, *52*(4), 421–427. https://doi.org/10.1080/00140130802707691

Buckley, J. P. and Borg, G. A. V. (2011). Borg's scales in strength training; from theory to practice in young and older adults. *Applied Physiology, Nutrition and Metabolism*, *36*(5), 682–692. https://doi.org/10.1139/h11-078

Cabral, L. L., Lopes, P. B., Wolf, R., Stefanello, J. M. F. and Pereira, G. (2017). A systematic review of cross-cultural adaptation and validation of Borg's Rating Of Perceived Exertion Scale. *Journal of Physical Education (Maringa)*, *28*(1). https://doi.org/10.4025/jphyseduc.v28i1.2853

Cabral, L. L., Nakamura F. Y., Stefanello, J. M. F., Pessoa L.C.V., Smirmaul B.P.C. and Pereira, G. (2020). Initial validity and reliability of the Portuguese Borg Rating of Perceived Exertion 6-20 Scale. *Measurement in Physical Education and Exercise Science, 1-12*. DOI: 10.1080/1091367X.2019.1710709

Chao, C. H. N., Costa, E. C., Okano, A. H., Farias Jr, T. de B., Farias Jr., L. F. and Elsangedy, H. M. (2014). Rating of perceived exertion and affective responses during thai chi chuan. *Perceptual & Motor Skills: Physical Development & Measurement*, *118*(3), 1–14. https://doi.org/10.2466/10.06.PMS.118k27w5

Chen, M. J., Fan, X. and Moe, S. T. (2002). Criterion-related validity of the Borg ratings of perceived exertion scale in healthy individuals: A meta-analysis. *Journal of Sports Sciences*, *20*(11), 873–899. https://doi.org/10.1080/026404102320761787

Chung, P.-K., Zhao, Y. and Liu, J.-D. (2015). A Brief Note on the Validity and Reliability of the Rating of Perceived Exertion Scale in Monitoring Exercise Intensity Among Chinese Older Adults in Hong Kong. *Perceptual & Motor Skills*, *121*(3), 805–809. https://doi.org/10.2466/29.PMS.121c24x8

Colado, J. C., Pedrosa, F. M., Juesas, A., Gargallo, P., Carrasco, J. J., Flandez, J., … Naclerio, F. (2018). Concurrent validation of the OMNI-Resistance Exercise Scale of perceived exertion with elastic bands in the elderly. *Experimental Gerontology*, *103*, 11–16. https://doi.org/10.1016/j.exger.2017.12.009

Colberg, S. R., Swain, D. P. and Vinik, A. I. (2003). Use of heart rate reserve and rating of perceived exertion to prescribe exercise intensity in diabetic autonomic neuropathy. *Diabetes Care*, *26*(4), 986–990. https://doi.org/10.2337/diacare.26.4.986

Conlon, J. A., Haff, G. G., Tufano, J. J. and Newton, R. U. (2015). Application of session rating of perceived exertion among different models of resistance training in older adults. *J Strength Cond Res*, *29*(12), 3439–3446.

Currell, K. and Jeukendrup, A, E. (2008). Validity, Reliability and Sensitivity of Measures of Sport Perforomance. *Sports Medicine*, *38*(4), 297–316. https://doi.org/10.2165/00007256-200838040-00003

Desgorces, F. D., Thomasson, R., Aboueb, S., Toussaint, J. F. and Noirez, P. (2015). Prediction of one-repetition maximum from submaximal ratings of perceived exertion in older adults pre- and post-training. *Aging Clinical and Experimental Research*, *27*(5), 603–609. https://doi.org/10.1007/s40520-015-0334-3

Donath, L., Zahner, L., Cordes, M., Hanssen, H., Schmidt-trucksäss, A. and Faude, O. (2013). Recommendations for Aerobic Endurance Training Based on Subjective Ratings of Perceived Exertion in Healthy Seniors. *Journal of Agining and Physical Activity*, *21*, 100–111.

Dunbar, C. C. and Kalinski, M. I. (2004). Using rpe to regulate exercise intensity during a 20-week training program for postmenopausal women : a pilot study. *Perceptual & Motor Skills: Physical Development & Measurement*, *99*, 688–690.

Eng, J. J., Chu, K. S., Dawson, A. S., Kim, M. and Hepburn, K. E. (2002). Functional Walk Tests in Individuals With Stroke Relation to Perceived Exertion and Myocardial Exertion. *Stroke*, *33*, 756–761.

Elhadi, M. M. O., Ma, C. Z., Wong, D. W. C., Wan, A. H. P. and Lee, and W. C. C. (2016). Comprehensive gait analysis of healthy older adults who have undergone long-distance walking. *Journal of Aging and Physical Activity,* 25(3),367-377. https://doi.org/10.1123/japa.2016-0136

Fairman, C. M., Lafountain, R. L., Lucas, A. R. and Focht, B. C. (2018). Monitoring resistance exercise intensity using ratings of perceived exertion in previously untrained patients with prostate cancer undergoing androgen deprivation therapy. *Journal of Strength and Conditioning Research*, *32*(5), 1360–1365. https://doi.org/10.1519/JSC.0000000000001991

Follador, L., Alves, R. C., Ferreira, S. dos S., Silva, A. C. and Silva, S. G. D. (2019). Perceived Exertion and Affect From Tai Chi, Yoga, and Stretching Classes for Elderly Women. *Perceptual and Motor Skills*, *126*(2), 223–240. https://doi.org/10.1177/0031512518823661

Fragala-Pinkham, M., O'neil, M. E., Lennon, N., Forman, J. L. and Trost, S. G. (2015). Validity of the OMNI rating of perceived exertion scale for children and adolescents with cerebral palsy. *Developmental Medicine and Child Neurology*, *57*(8), 748–753. https://doi.org/10.1111/dmcn.12703

Gearhart, R. F. J., Lagally, K. M., Riechman, S. E. and Andrews, R. D. (2008). RPE at Relative intensities after 12 weeks o f resistance-exercise training by older adults. *Perceptual & Motor Skills*, *106*, 893–903.

Gearhart, R. F. J., Lagally, K. M., Riechman, S. E. and Andrews, R. D. (2011). Safety of using the adult OMNI Resistance Exercise Scale to determine 1-RM in older men and women. *Perceptual & Motor Skills*, *113*(2), 671–676. https://doi.org/10.2466/10.15.PMS.113.5.671-676

Gearhart, R. F. J., Lagally, K. M., Riechman, S. E., Andrews, R. D. and Robertson, R. J. (2009). Strength Tracking Using the OMNI Resistance Exercise Scale in Older Men and Women. *The Journal of Strength and Conditioning Research*, *23*(3), 1011–1015. https://doi.org/10.1519/JSC.0b013e3181a2ec41

Guidetti, L., Broccatelli, M., Baldari, C. and Buzzachera, C. F. (2011). Validation of the italian version of the omni scale of perceived exertion in a sample of italian-speaking adults. *Perceptual & Motor Skills*, *112*(1), 201–210. https://doi.org/10.2466/06.07.13.27.PMS.112.1.201-210

Hu, L., Mcauley, E., Motl, R. W. and Konopack, J. F. (2007). Influence of Self-Efficacy on the Functional Relationship Between Rating of Perceived Exertion and Exercise Intensity. *Journal of Cardiopulmonary Rehabilitation and Prevention*, *27*, 303–308.

Iellamo, F., Manzi, V., Caminiti, G., Vitale, C., Massaro, M., Cerrito, A., … Volterrani, M. (2014). Validation of rate of perceived exertion-based exercise training in patients with heart failure : Insights from autonomic nervous system adaptations. *International Journal of Cardiology*, *176*(2), 394–398. https://doi.org/10.1016/j.ijcard.2014.07.076

Kakarot, N. and Müller, F. (2014). Assessment of physical strain in younger and older subjects using heart rate and scalings of perceived exertion, *Ergonomics*, (October), 37–41. https://doi.org/10.1080/00140139.2014.910613

Law, M., Stewart, D., Pollock, N., Letts, L., Bosch, J. and Westmoreland, M. (1998). Guidelines for Critical Review form- Quantitative Studies. *Quantitative Review Form-Guidelines*, 1–11. https://doi.org/10.1088/1751-8113/44/8/085201

Lazzarini, B. S. R., Dropp, M. W. and Lloyd, W. (2017). Upper-extremity explosive resistance training with older adults can be regulated using the rating of perceived exertion. *Journal of Strength and Conditioning Research*, *31*(3), 831–836.

Lins-Filho O. L., Santos T.M., Ritti-Dias R.M., Damasceno V.O. and Ferreira D.K.S. (2019). The Absolute and Relative Reliability of Psychophysiological Responses to Self-Selected exercise intensity in Elderly Women. *Research Quarterly y for exercise and sport,* 90(3):270-275. Doi: 10.1080/02701367.2019.1593922

Magal, M. and Zoeller, R. F. (2005). A pilot study comparing physiological responses of phase iii cardiac patients to recumbent and upright exercise using the rpe scale. *Perceptual & Motor Skills*, *100*, 357–361.

Milot, M. H., Léonard, G., Corriveau, H. and Desrosiers, J. (2019). Using the borg rating of perceived exertion scale to grade the intensity of a functional training program of the affected upper limb after a stroke: A feasibility study. *Clinical Interventions in Aging*, *14*, 9–16. https://doi.org/10.2147/CIA.S179691

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G. and Group, T. P. (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement (Reprinted from Annals of Internal Medicine). *Physical Therapy*, *89*(9), 873–880. https://doi.org/10.1371/journal.pmed.1000097

Morrin, N. M., Stone, M. R., Swaine, I. L. and Henderson, K. J. (2018). The use of the CR-10 scale to allow self-regulation of isometric exercise intensity in pre-hypertensive and hypertensive participants. *European Journal of Applied Physiology*, *118*(2), 339–347. https://doi.org/10.1007/s00421-017-3774-y

Murrock, C. J. (2002). The effects of music on the rate of perceived exertion and general mood among coronary artery bypass graft patients enrolled in cardiac rehabilitation phase II. *Rehabilitation Nursing : The Official Journal of the Association of Rehabilitation Nurses*, *27*(6), 227–231. https://doi.org/10.1002/j.2048-7940.2002.tb02018.x

Myers, J., Atwood, J. E., Sullivan, M., Forbes, S., Friis, R., Pewen, W. and Froelicher, V. (1987). Perceived exertion and gas exchange after calcium and p-blockade in atria1 fibrillation. *J. Appl. Physiol.*, *63*(1), 97–104.

Myers, J., Atwood, J. E., Sullivan, M., Forbes, S., Friis, R., Pewen, W. and Froelicher, V. (1987). Perceived exertion and gas exchange after calcium and p-blockade in atria1 fibrillation. *J. Appl. Physiol.*, *63*(1), 97–104.

Noble, B. J. and Robertson., R. J. (1996). *Perceived exertion.* Champaign, IL: Human Kinetics.

Pageaux, B. (2016). Perception of effort in Exercise Science: Definition, measurement and perspectives. *European Journal of Sport Science*, *16*(8), 885–894. https://doi.org/10.1080/17461391.2016.1188992

Pereira, G., de Souza, D. M., Reichert, F. F. and Smirmaul, B. P. C. (2014). Evolution of perceived exertion concepts and mechanisms : a literature review. *Revista Brasileira de Cineantropometria e Desempenho Humano*, *16*(5), 579–587. https://doi.org/10.5007/1980-0037.2014v16n5p579

Pincivero, D. M. (2011). Older adults underestimate RPE and knee extensor torque as compared with young adults. *Medicine and Science in Sports and Exercise*, *43*(1), 171–180. https://doi.org/10.1249/MSS.0b013e3181e91e0d

Reychler, G., Mottart, F., Boland, M., Wasterlain, E., Pieters, T., Caty, G. and Liistro, G. (2015). Influence of Ambient Music on Perceived Exertion During a Pulmonary Rehabilitation Session : A Randomized Crossover Study. *Respiratory Care*, *60*, 1–7. https://doi.org/10.4187/respcare.03671

Robertson, R. J., Goss, F. L., Andreacci, J. L., Dubé, J. J., Rutkowski, J. J., Snee, B. M., … Metz, K. F. (2005). Validation of the children's OMNI RPE scale for stepping exercise. *Medicine and Science in Sports and Exercise*, *37*(2), 290–298. https://doi.org/10.1249/01.MSS.0000149888.39928.9F

Robertson, R. J., Goss, F. L., Bell, J. A., Dixon, C. B., Gallagher, K. I., Lagally, K. M., … Gallagher, J. D. (2002). Self-regulated cycling using the children's OMNI Scale of Perceived Exertion. *Medicine and science in sports and exercise*, 13–15.

Row, B. S., Knutzen, K. M. and Skogsberg, N. J. (2012). Regulating explosive resistance training intensity using the rating of perceived exertion. *Journal of Strenght and Conditioning Research*, *26*(3), 664–671.

Sage, M., Middleton, L. E., Tang, A., Sibley, K. M., Brooks, D. and Mcilroy, W. (2013). Validity of Rating of Perceived Exertion Ranges in Individuals in the Subacute Stage of Stroke Recovery. *Topics in Stroke Rehabilitation*, *20*(6), 519–527. https://doi.org/10.1310/tsr2006-519

Serafim, T. H. S., Tognato, A. C., Nakamura, P. M., Queiroga, M. R., Pereira, G., Nakamura, F. Y. and Kokubun, E. (2014). Development of the Color Scale of Perceived Exertion: Preliminary Validation. *Perceptual and Motor Skills*, *119*(3), 884–900. https://doi.org/10.2466/27.06.PMS.119c28z5

Shigematsu, R., Ueno, L. M., Nakagaichi, M., Nho, H. and Tanaka, K. (2004). Rate of perceived exertion as a tool to monitor cycling exercise intensity in older adults. *Journal of Aging and Physical Activity*, 12(1), 3-9.

Sidney, K. H. and Shephard, R. J. (1977). Perception of exertion in the elderly, effects of aging, mode of exercise and physical training. *Perceptual and Motor Skills*, *44*(3 I), 999–1010. https://doi.org/10.2466/pms.1977.44.3.999

Souza, D. M. de, Lopes, P. B., Marcora, S. M., Robertson, R. J., Rodacki, A. L. F., Nakamura, F. Y. and Pereira, G. (2018). Validity, Reliability, and Diagnostic Accuracy of Ratings of Perceived Exertion to Identify Dependence in Performing Self-care Activities in Older Women. *Experimental Aging Research*, *44*(5), 1–14. https://doi.org/10.1080/0361073X.2018.1521492

Streiner, D. L., Norman, G. R. and Cairney, J. (2015). Health Measurement Scales: A practical guide to their development and use. *Oxford, UK: Oxford University Pres*s. https://doi.org/10.1378/chest.96.5.1161.

Sumpter, D. A., García, A. J. and Pozo, J. (2015). The relationship between perceived exertion, physical activity and quality of life in older women. *Revista de Psicologia Del Deporte*, *24*, 281–287.

Terziyski, K., Marinov, B., Hodgev, V., Tokmakova, M. and Kostianev, S. (2010). Standardized Peak Exercise Perception Score. *Journal of Cardiopulmonary Rehabilitation and Prevention*, *30*, 40–46.

Valiani, V., Corbett, D. B., Knaggs, J. D. and Manini, T. M. (2016). Metabolic Rate and Perceived Exertion of Walking in Older Adults with Idiopathic Chronic Fatigue. *The Journals of Gerontology*. *71*(11), 1444–1450. https://doi.org/10.1093/gerona/glw108

Yu, F. and Bil, K. (2010). Correlating heart rate and perceived exertion during aerobic exercise in Alzheimer's Disease. *National Institute of Health*, *12*(3), 375–380. https://doi.org/10.1111/j.1442-2018.2010.00543.x.

Yu, F., Demorest, S. L. and Vock, D. M. (2015). Testing a modified perceived exertion scale for Alzheimer 's disease. *PsyCh Journal*, *4*, 38–46. https://doi.org/10.1002/pchj.82

White, M. M., Morejon, O. N., Liu, S., Lau, M. Y., Nam, C. S. and Kaber, D. B. (2017). Muscle loading in exoskeletal orthotic use in an activity of daily living. *Applied Ergonomics*, *58*, 190–197. https://doi.org/10.1016/j.apergo.2016.06.010

Wong, D. G.; Rechnitzer, P. A.; Cunningham, D. A. and Howard, H. J. (1990). Effect of an exercise program on the perception of exertion in males at retirement. *CA. J. Spt. Sci.*, *15*(4), 249–253.