ECP Espiral. Cuadernos del Profesorado
Vol.14, nº 28
Marzo 2021 (1er semestre)
Multidisciplinary Journal of Education

Systematic revision of the standard operating procedures for the evaluation of lower limbs through the jumps

Revisión sistemática de los procedimientos operativos estándar para la evaluación de los miembros inferiores a través de los saltos

Luca Petrigna[1], Antonio Palma[1], Manuel Gómez-López[2], y Antonino Bianco[1]

[1]University of Palermo, Italy; [2]University of Murcia, Spain

Abstract

Background: Standard Operating Procedures (SOPs) are step by step guidelines and they exist for vertical jumps but not for the Standing Long Jump (SLJ). The SLJ is a test widely adopted to measure lower limb strength, especially in the health context. Because the SLJ identifies people who are not developing healthy fitness habits, this review provides information about protocols adopted for the SLJ test and, eventually, SOPs will be created. Methods: Only English written original articles concerning children and adolescents were included. PRISMA statement was partially adopted and followed. Results: 73 studies were included. Few studies adopted protocols created previously and each procedure adopted was analyzed to detect the common aspects. Conclusion: SOPs were not adopted for the SLJ test and, consequently, a standardized procedure was proposed.

Keywords: Horizontal jump; Standing long jump; Standard operating procedure; SOP; Evaluation.

Resumen

Antecedentes: Existen Procedimientos Operativos Estándar (SOP) para los saltos verticales, pero no para el salto de longitud (SLJ) aunque esta prueba mide la fuerza de los miembros inferiores. Debido a que la SLJ identifica a las personas que no están desarrollando hábitos saludables y de condición física, esta revisión proporciona información sobre los protocolos adoptados para la prueba de SLJ y, eventualmente, se crearán SOPs. Métodos: Sólo se incluyeron artículos originales escritos en inglés sobre niños y adolescentes. La declaración de PRISMA fue parcialmente adoptada y seguida. Resultados: Se incluyeron 73 estudios. Pocos estudios adoptaron protocolos creados previamente. Conclusiones: No se adoptaron los procedimientos operativos estándar para la prueba de SLJ y, en consecuencia, se propuso un procedimiento estandarizado.

Palabras Clave: Salto horizontal; Salto de longitud; Procedimiento operativo estándar (SOP); Evaluación.

Received: 26/11/2020
Acepted: 15/12/2020

Corresponding author: Manuel Gómez-López, University of Murcia, Spain
Email: mgomezlop@um.es

Introduction

A Standard Operating Procedure (SOP) is a useful instrument that makes the test replicable because it is a "laboratory manuals" that describe step by step the procedure (Angiuoli et al., 2008; Tuck et al., 2009). A Standard Operating Procedure increases the quality of the research and it is widely adopted in a lot of fields (Angiuoli et al., 2008) such as biology (Roseti et al., 2015) or medicine (Ntaios et al., 2015; Rognas et al., 2013; Sherren et al., 2014). Because a SOP is useful, a review has been written to create Standard Operating Procedures (SOPs) also in the Sports Sciences field and it has been decided to study the vertical jumps, in the specific, for the countermovement jump (CMJ) and the squat jump (SJ) (Petrigna et al., 2019). The two vertical jumps are widely adopted by the literature (Liebermann & Katz, 2003; Duthie, 2006) and the CMJ and SJ are considered valid and reliable (Markovic et al., 2004) also in children (Fernandez-Santos et al., 2015) to evaluate explosive muscle strength (Sargent, 1921; Sargent, 1924; Bosco, 1979; Bosco & Komi, 1980; Bosco & Viitasalo, 1982). Unfortunately, when the review (Petrigna et al., 2019) was performed these two jumps presented a lack of robust and consistent testing methods (Eagles et al., 2015) and the objective of that review was to provide information about the testing method, to find the common aspects between the protocols examined and to create a SOP that considered each jumping phase.

As the CMJ and the SJ, in different fitness test batteries create for school-children there is a test widely adopted and this is the Standing Long Jump (SLJ) also called Standing Broad Jump (SBJ) (Bianco et al., 2015; Castro-Pinero, Ortega, et al., 2010; Ortega et al., 2011; Ruiz et al., 2011). The SLJ is a test useful to measure lower limb muscular fitness and, more specifically, explosive muscular strength (Ortega et al., 2015) also in young people (Castro-Pinero, Ortega, et al., 2010). The SLJ test is considered the most valid and reliable field-based muscular fitness test in children and adolescents (Artero et al., 2012; Castro-Pinero, Ortega, et al., 2010), even when it is compared with isokinetic strength exercises (Artero et al., 2012). The SLJ test presents a strong association with the 1RM leg extension (Faigenbaum et al., 2003; Fernandez-Santos et al., 2015) and several studies have found a significant correlation with the vertical jump tests (Castro-Pinero, Ortega, et al., 2010).

The SLJ is also a field test (Artero, Espana-Romero, et al., 2011; Ruiz et al., 2011) and this kind of tests are easier to administer, faster and cheaper (Heyward, 1991), and consequently are ideal in population-based studies, such as in the school setting (Artero, Espana-Romero, et al., 2011). From a public health perspective, the inclusion of SLJ test in health surveillance could be justifiable, and schools may be an ideal setting for monitoring youth fitness to identify those with poor strength (Ramirez-Velez et al., 2015). As the literature suggests, the SLJ test is also a valid field measure of anaerobic power useful to monitor the training and early sports talent identification (Krishnan, 2017).

The SLJ test is a tool used to evaluate the strength of people. Because many activities pattern that impact physical fitness begun in early childhood, and it is important to adopt a valid, reliable, and feasible measures to identify children who are not developing healthy fitness habits (Davis et al., 2008; Faigenbaum et al., 2011; Garber et al., 2011); this review aimed to gather information on protocols adopted for the assessment of muscular fitness through the SLJ test in children and adolescents, and to eventually provide SOPs.

Method

Materials

This review of literature partially adopted the key points stated in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009) and protocol was registered in PROSPERO (ID=CRD42019126698).

Databases searched for the articles were PubMed (NLM), Web of Science (TS) and Scopus using the terms in the search field "title" and/or "topic" of each database. The search strategy included and matched the terms of keywords 1, 3 and 3 using the Boolean operator "AND". Keywords1: "standing long jump*", "standing broad jump*", "horizontal jump*", "long jump*", "standing jump*"; Keywords2: "maximal dynamic strength", "field-based physical fitness test*", "fitness-test battery*", "field test*", "physical fitness", "muscle strength", "strength", "resistance training", "physical education", "reliability" and "validity"; Keywords3: "youth", "preadolescence*", "adolescent*", "young".

The PICO-S criteria (Population, Intervention, Comparison, Outcomes, Study design) were used to establish the eligibility criteria. The included population comprised of healthy males and female children and adolescents. Young adults, adults and the elderly were excluded. Any type of intervention or comparison if a protocol of the SLJ test was present, was included. Regarding the study design, original articles were eligible for further analysis in which the SLJ test performance was used to assess lower limb muscular fitness. Quantitative, qualitative and mixed-methods designs were included while reviews, meta-analysis, abstracts, scientific conference abstracts, citations, opinion pieces, books, book reviews, letters, statements, editorials, non-peer-reviewed journal articles, and commentaries in the review were not included. The country of origin was not a restriction criterion but only English written manuscripts were considered.

The screening was performed from January 1, 2007 to December 21, 2017. All articles selected were transferred and scanned for duplicates to the EndNote X8 software. The full text of eligible articles was then examined by two independent reviewers who worked independently. The selection was performed by the titles, the abstract and in the full-text by the two investigators that were not blinded to the authors or affiliation. A third investigator was involved to make the final decision if there was disagreement between the investigators.

The information "lead author, year of publication, sample size, participants' age, number of males and females, objective of the study, SLJ test information (technique of the jump, number of jumps performed, other information)" were inserted into a Microsoft Excel (Microsoft Corp, Redmond, Washington) spreadsheet. The information was extracted from any section of the manuscript. Tables were created to analyzed the literature took in the examination and a descriptive narrative synthesis has been adopted to discuss the results.

Results

A total of 73 studies were considered after the literature search (Table 1).

Table 1

Characteristics of the studies included in the review

Study	Subjects (Female) [Male]	Age	Main objective	Muscular tests
Andersen et al., 2017	1129	10	Examine how CF, MF, PA and waist circumference influence quality of life	HG, SBJ
Artero, Ortega, et al., 2010	2567 (1426) [1141]	12-17	Examine the association between breastfeeding duration and CF, MF	HG, SLJ
Artero, Espana-Romero, et al., 2010	2474 (1278) [1196]	13-18	Investigate differences in health-related fitness classed as underweight, normal weight, overweight or obese	HG, BAHT, SLJ
Artero, Ruiz, et al., 2011	709 (363) [346]	12-17	Examine the associations of CF and MF with clustered metabolic risk in adolescents	HG, SLJ
Artero et al., 2014	639 (343) [296]	12-17	Examine the association of MF with inflammatory biomarkers	HG, SLJ
Ayan-Pérez et al., 2016	163 (91) [72]	4-5	Assess the test-retest reliability of the Sargent jump for VJ performed by preschoolers.	VJ, SLJ
Cadenas-Sánchez, Henriksson, et al., 2017	307	4	Examine the association between parental BMI and their offspring's body composition, PF and lifestyle	HG, SLJ
Cadenas-Sánchez, Martínez-Tellez, et al., 2016	161 (69) [92]	3-5	Examine the feasibility and reliability of a field-based fitness-test battery in preschool children	HG, SLJ
Cadenas-Sánchez, Vanhelst, et al., 2017	444 (233) [211]	12-17	Examine the association of health-related PF components and accurate measures of fatness with attention	HG, SLJ
Castro-Pinero et al., 2009	2778 (1265) [1513]	6-18	Provide percentiles values for 9 different muscular strength tests for Spanish children.	MBT, VJ, BAHT, SBJ, ST

Castro-Pinero, Ortega, et al., 2010	94 (45) [49]	6-17	Examine the association among different measures of lower body muscular strength and the association between measures of lower and upper body muscular strength	SLJ, VJ, SJ, CMJ, MBT, ST
Ceschia et al., 2016	2411	7-11	Analyze the association between PF and BMI in pre-pubertal children.	HG, SLJ, SJ, MBT
Ciesla et al., 2017	28623 (14020) [14633]	6-7	Determine the influence of birthweight on the PA level	ST, SLJ, BAHT
Cuenca-García et al., 2013	2084	12-17	Explore the clustering of different lifestyle behaviors and whether this clustering differ by gender, age, and health-related fitness.	HG, SBJ
Cuenca-García, 2013	2148	12-17	Examine the association of breakfast consumption with objectively measured and self-reported PA, sedentary time and PF.	HG, SBJ
Czyz et al., 2017	641	10-15	Examine the association between obesity and PA, PF and sedentary behavior and diet	HG. SLJ, ST
Dallolio et al., 2016	241	8-10	Evaluate the effectiveness and feasibility of a school-based physical education intervention aimed to increasing the levels of moderate-to-vigorous PA	HG, SLJ
De la Cruz-Sánchez & Pino-Ortega, 2010	293 (156) [137]	10	Analyze differences according to sex in physical performance in children as well as other health-related variables.	HG, horizontal jump
De Miguel-Etayo et al., 2014	10302 (50.7%) [49.3%]	6-11	Report sex and age-specific fitness reference standards in European children.	HG, SLJ
Dobosz et al., 2015	49281 (23594) [25687]	7-19	Report gender and age-specific percentile values for 14 commonly used-field-based PF tests	HG, SBJ, ST, BAHT
Espana-Romero et al., 2010	138	6-18	Determine the reliability, feasibility and safety of a health-related fitness test battery.	HG, SLJ, 20mSRT
Esteban-Cornejo et al., 2017	110	8-11	Examine the association between PF and brain volume and to determine if are correlated with academic results in obesity	HG, SLJ
Fernández-Santos et al., 2015	363 (168) [195]	6-12	Analyze the reliability and the criterion-related validity of several lower-body muscular power tests in children.	SLJ, CMJ, SJ AJ, ST
Fjortoft et al., 2011	195 (101) [94]	5-12	Estimate the feasibility, internal consistency, convergent construct validity, and test-retest reliability of a test battery	SBJ, MBT
García-Hermoso et al., 2017	36870	14	Examine the combined association between body fat, PA with academic results	SLJ
Gracia-Marco et al., 2017	1481 (51%) [49%]	12-17	Association between amino acid intake and PF	HG, SLJ
Gulias-González et al., 2014	2330	6-17	Estimated the prevalence of underweight, overweight and obesity of children and adolescents from Spain.	HG, SBJ
Ho et al., 2017	664 (386) [278]	12	Assess the effectiveness of a positive youth development based sports mentorship program on the physical and mental well-being in adolescent	HG, SLJ, sit up
Ishihara et al. 2017	68 (34) [34]	6-12	Evaluate the relationship between sports experience and executive function in children while controlling for PA and fitness.	SLJ, sit up
Jiménez-Pavon et al., 2010	1795 (931) [833]	12-18	Examine the influence of socioeconomic status on fitness and fatness	SLJ
Jiménez-Pavón, Ortega, Valtuena, et al., 2012	1053 (554) [499]	12-17	Examine the association of muscular strength with markers of insulin resistance	HG, SLJ
Jiménez-Pavón, Ortega, Artero, et al., 2012	902 (509) [393]	12-17	Examine the association of PA and fitness with leptin concentrations	HG, SLJ
Jones & Lorenzo, 2013	157 (104) [53]	12	Assess power, speed and agility in athletic, preadolescent and determine how agility related to muscular strength and power.	VJ, SLJ, MBT, curl ups,
Latorre-Román et al., 2015	553 (279) [274]	3-6	Determine the test-retest reliability of the Fitness Test Battery in children	SBJ
Latorre-Román et al., 2016	1012 (510) [502]	3-6	Analyze the association between intellectual maturity and PF and motor fitness in preschool children	SBJ
Leppanen et al., 2017	138	4	Investigate longitudinal associations of objectively measured PA and sedentary behavior with body	SLJ, HG

			composition at a 12 month follow up in healthy 4 year old child	
Lopes et al., 2017	4567 (2505) [2062]	6-16	Evaluate the linear and curvilinear relationship between BMI and PF	SLJ, MBT
Luz et al., 2017	546 (268) [278]	7-14	Analyses the associations between motor competence and its components, with health-related fitness	HG, SLJ
Martín-Matillas et al., 2012	3288 (52%) [48%]	12-17	Examine the relationship between relatives' PA engagement and encouragement of adolescents' PF	SLJ
Martínez-Tellez et al., 2016	403 (42.2%) [57.8%]	3-5	Investigate whether health-related PF is associated with total and central body fat in preschool children	HG, SLJ
Milliken et al., 2008	90 (39) [51]	7-12	Characterize and identify correlates of muscular strength in children.	HG, VJ, SLJ
Moliner-Urdiales, Ortega, et al., 2010	363 (180) [183]	12-17	Analyze the association of objectively assessed PA with muscular strength and fat-free mass	HG, SBJ, SJ, CMJ, AJ
Moliner-Urdiales, Ruiz, et al., 2010	399 (184) [215]	12-17	Analyze the secular trends in health-related PF in Spanish adolescents.	HG, BHA, SBJ
Moliner-Urdiales et al., 2011	363 (186) [177]	12-17	Examine the association of health-related PF with total and central body fat in adolescents.	HG, SBJ, AJ
Nakata et al., 2017	3610	7-15	Investigate characteristics of the relative age effect among a general sample of elementary and junior students	SLJ, HG, ST, MBT
Negra et al., 2017	[37]	12	Examined the effects of plyometric training on stable surfaces compared to combined PT on stable	CMJ, SLJ
Nhantumbo et al., 2013	794 (384) [456]	6-17	Determine if malnourished youths from rural African areas have lower levels of PF and PA.	HG, SBJ, flexed AH
Ortega, Artero, et al., 2008	123 (54) [69]	14	Examine the reliability of a set of health-related PF tests used in the HELENA Study on lifestyle and nutrition	HG, SBJ, SJ, CMJ, AJ, BAHT
Ortega et al., 2011	3428 (1845) [1683]	12-17	Report sex- and age-specific PF levels in European adolescents.	HG, SBJ, SJ, CMJ, AJ, BAHT
Ortega et al., 2017	44	9-10	Examine the association health-related PF components with subcortical brain structure	HG, SLJ
Pereira et al., 2017	1101 (525) [576]	9-20	Investigate biological, behavioral and sociodemographic correlates of intrapair similarities, and estimates sibling resemblance in health-related PF	HG, SLJ
Ramírez-Vélez et al., 2015	229 (105) [124]	9-18	Examine the reliability of health-related PF tests	HG, SLJ, VJ
Ramírez-Vélez, Cruz-Salazar, et al., 2017	1873 (54.5%) [45.5%]	9-18	Generate normative values for the standing long jump test in 9 17 years old and differences of age and sex	SBJ, HG
Ramírez-Vélez, Martínez, et al., 2017	8034 (4546) [3488]	9-18	Generate normative values for the standing long jump test in 9 17 years old and differences of age and sex	SLJ
Ramírez-Vélez, García-Hermoso, et al., 2017	2877 (54.5%) [45.5%]		Examine the validity and reliability of the international fitness scale	SLJ, HG
Ranson et al., 2015	1757 (835) [922]	8-12	Investigate correlations between 2D:4D and fitness levels in children	HG, SBJ
Rodríguez-Ayllón et al., 2018	110 (35%) [65%]	10	Examine the association of PF with psychological distress and wellness in obese children	HG, SBJ 20mSRT
Ruiz et al., 2010	1820 (958) [862]	13-18	Examine the association of participation in physical sports activity during leisure time, sedentary behaviors, CF, MF and weight status with cognitive performance	HG, SLJ
Sacchetti et al., 2012	497 (241) [256]	8-9	Analyze the main conditioning and coordinative abilities in children.	MBT, SLJ
Sandercock et al., 2017	52187	14-16	Determine the associations between socioeconomic status and PF	SLJ, HG
Schmidt et al., 2017	236 (124) [112]	10-12	Examine the mediating role of executive function in the relationship between motor ability and academic achievement	SLJ
Segura-Jiménez et al., 2016	482 (226) [256]	6-18	Examine the independent and combined association of objectively measured PA and PF with CMeSRF and to test the mediating effect of PF in the association of PA with CMetSRT	HG, SLJ

Sigmundsson et al., 2017	67 (31) [36]	9-12	Association of motor competence and PF with reading skills in children	SBJ, MBT, TBT
Smith et al., 2017	548 (272) [276]	14	Examine the prevalence and correlated of adolescents resistant training skill compet	SLJ, ST
Tan et al., 2017	104 (51) [53]	5	Explore the effects of exercise training on body composition, cardiovascular function and PF	HG, SLJ
Tercedor et al., 2017	300	8-9	Evaluate the effectiveness of 5 innovative simple and feasible interventions to improve PF	HG, SLJ
Tishukaj et al., 2017	354 (159) [195]	14	Examine anthropometric and PF parameters in 14–15-year-old	HG, SLJ, CMJ
Ubago-Guisado et al., 2017	[121]	13	Investigated the associations between fitness indices and bone outcomes in male	VJ, SLJ
Valtuena et al., 2013	1006 (536] [470]	12-17	Determine how body composition and PF are related to 25-hydroxyvitamin D concentrations in European adolescents.	HG, SLJ
van Deutekom et al., 2013	200	8-9	Examine the association of birth weight and infant growth trajectories with aerobic fitness, muscular strength and assess sedentary behavior and PA levels	SBJ, HG
Vanhelst et al., 2016	174	8-16	Examine the reliability of health-related PF tests used in a health promotion program.	MBT, SLJ
Welk et al., 2015	2602	10-18	Examine region, age, sex profiles of PF in Hungarian youth,	HG, SBJ, ST
Winwood, Accepted	[62]	14-15	Compared the effects of 7 weeks of body weight, mobility and resistance training	CMJ, SLJ, MBT, ST

Note: AJ: Abalakov jump. BAHT: Bent Arm Hang Test. CMJ: Counter Movement Jump. CMJa: CMJ with arms. DJ: Drop Jump. HG: Handgrip. ST: strength test. PF: physical fitness. PP: physical performance. RJ: Rocket Jump. RLJ: Reactive Long Jump. SBJ: Standing Broad Jump. SJ: Squat Jump. SLJ: Standing Long Jump.

Most of the studies suggested to the participants to jump as far as possible with feet together from behind a line and feet shoulder's width apart (16 studies). The swing of the arms was allowed in nine studies while the bending of the knees eight studies. Most of the authors used the best of two trials (16 authors) while five authors used the best of three trials. If the participants felt backward, the jump was repeated (Ayan-Pérez et al., 2016; Cadenas-Sánchez, Martínez-Tellez, et al., 2016). Other studies adopted different indications while few studies did not provide information about the protocol, results are synthetized in table 2.

Table 2

Information regarding the standing long jump in the studies included

Study	Protocol
Andersen et al., 2017	(Artero, España-Romero, et al., 2011; Castro-Pinero, Artero, et al., 2010)
Artero, Ortega, et al., 2010	Standing behind a line with feet approximately shoulder's width apart. Jump as far as possible with feet together. Swinging of the arms and bending of the knees were allowed. Best of 2
Artero, España-Romero, et al., 2010	Jump with feet separate from each other approximately at the shoulder's width. Best of 2
Artero, Ruiz, et al., 2011	Standing behind a line with feet approximately shoulder's width apart. Jump as far as possible with feet together. Swinging of the arms and bending of the knees were allowed. Best of 2
Artero et al., 2014	Standing behind a line with feet approximately shoulder's width apart. Jump as far as possible with feet together. Swinging of the arms and bending of the knees were allowed. Best of 2
Ayan-Pérez et al., 2016	Jump as far as possible, taking off with both feet. Bending the knees and swinging the arms was allowed. Best of 2. If they fell backwards on their hands during or after landing, that jump was taken as a failed attempt, and a repeat jump was permitted.
Cadenas-Sánchez, Henriksson, et al., 2017	(Leppanen et al., 2016), (Cadenas-Sanchez, Martinez-Tellez, et al., 2016)
Cadenas-Sánchez, Martínez-Tellez, et al., 2016	Jump as far as possible with feet together (separate from each other approximately at the shoulder's width) and remaining upright. Best of 3 jumps. When the attempt was considered not valid it was needed to repeat it.
Cadenas-Sánchez, Vanhelst, et al., 2017	(Ortega et al., 2011)
Castro-Pinero et al., 2009	Push off vigorously and jump as far as possible. Land with the feet together and to

	stay upright. Best of 2. A further attempt was allowed if the subject fell backward or touched the mat with another part of the body.
Castro-Pinero, Ortega, et al., 2010	(Castro-Pinero et al., 2009), Best of 2
Ceschia et al., 2016	(Brunet et al., 2007), (Castro-Pinero et al., 2009), (Riddiford-Harland et al., 2006). Best of 2
Ciesla et al., 2017	Feet slightly apart. A 2-foot take-off and landing is used, with swinging of the arms and bending of the knees. Jump as far as possible, landing on both feet without falling backwards.
Cuenca-García et al., 2013	Best of 2
Cuenca-García, 2013	(Ortega et al., 2011)
Czyz et al., 2017	Double-foot take off from a half-squat posture and jumped forward as far as possible. The best of 3
Dallolio et al., 2016	Other protocol. Best of 2
De la Cruz-Sánchez & Pino-Ortega, 2010	Other protocol.
De Miguel-Etayo et al., 2014	(Castro-Pinero, Ortega, et al., 2010)
Dobosz et al., 2015	No info.
España-Romero et al., 2010	Standing with feet approximately shoulder’s width apart, jump as far forwards as possible. Best of 2
Esteban-Cornejo et al., 2017	(Castro-Pinero, Ortega, et al., 2010). Best of 3
Fernández-Santos et al., 2015	(Castro-Pinero et al., 2009)
Fjortoft et al., 2011	Stands with feet parallel and shoulder width apart. Upon a signal, swings the arms backward and forward and jumps with both feet simultaneously as far forward as possible. Best of 2
García-Hermoso et al., 2017	Push off vigorously and jump as far as possible. Land with the feet together and remain upright. Best of 2
Gracia-Marco et al., 2017	(Ortega, Artero, et al., 2008)
Gulias-González et al., 2014	Forward jump from standing position. Best of 2
Ho et al., 2017	(Ortega, Artero, et al., 2008), (Ortega, Ruiz, Castillo, & Sjostrom, 2008)
Ishihara et al. 2017	(Morita et al., 2016)
Jiménez-Pavón et al., 2010	Behind the starting line and push off vigorously and jump as far as possible
Jiménez-Pavón, Ortega, Valtuena, et al., 2012	Behind the starting line and to push off vigorously and jump as far as possible
Jiménez-Pavón, Ortega, Artero, et al., 2012	Best of 2
Jones & Lorenzo, 2013	Countermovement of the body and arms and jump. Best of 3
Latorre-Román et al., 2015	(Espana-Romero et al., 2010). Best of 2
Latorre-Román et al., 2016	(Schepers et al., 2012). Best of 2
Leppanen et al., 2017	(Cadenas-Sánchez, Nystrom, et al., 2016), (Leppanen et al., 2016), (Ortega et al., 2015)
Lopes et al., 2017	Other protocol. Best of 3
Luz et al., 2017	Jump with both feet simultaneously as far as possible. Best of 3.
Martín-Matillas et al., 2012	Best of 2. (Ortega, Artero, et al., 2008), (Ruiz et al., 2011)
Martínez-Téllez et al., 2016	Jump with the feet separate from each other approximately at the shoulder’s width. Best of 3
Milliken et al., 2008	Other protocol
Moliner-Urdiales, Ortega, et al., 2010	(Ortega, Artero, et al., 2008), (Ruiz et al., 2006)
Moliner-Urdiales, Ruiz, et al., 2010	(Ortega et al., 2005)
Moliner-Urdiales et al., 2011	(Ortega, Artero, et al., 2008)
Nakata et al., 2017	Other protocol.
Negra et al., 2017	Stand with their feet shoulder-width apart and arms loosely hanging down. Countermovement with their legs and arms and jumped at maximal effort in the horizontal direction. Participants had to land with both feet at the same time and were not allowed to fall forward or backward
Nhantumbo et al., 2013	EUROFIT protocol.
Ortega, Artero, et al., 2008	From a starting position, standing with feet shoulder’s width apart, jumps as far as possible with feet together.
Ortega et al., 2011	(Ortega, Artero, et al., 2008), (Ruiz, Gutierrez, et al., 2006)
Ortega et al., 2017	(Ortega, Artero, et al., 2008), (Ortega et al., 2011)
Pereira et al., 2017	No info.

Ramírez-Vélez et al., 2015	Push off vigorously and jump as far as possible. Land with the feet together and stay upright. Best of 2
Ramírez-Vélez, Cruz-Salazar, et al., 2017	(Espanol-Moya & Ramírez-Vélez, 2014)
Ramírez-Vélez, Martínez, et al., 2017	(Saint-Maurice et al., 2015). Average of 2
Ramírez-Vélez, García-Hermoso, et al., 2017	Jump as far as possible using a 2-footed take-off and landing technique. Flex and then extend their knees, ankles, and hips, and to swing their arms was allowed. The best of 2
Ranson et al., 2015	EUROFIT protocol.
Rodriguez-Ayllon et al., 2018	(Ruiz et al., 2011)
Ruiz et al., 2010	Land with both feet. Best of 2
Sacchetti et al., 2012	(Brunet et al., 2007), (Castro-Pinero et al., 2009), (Riddiford-Harland et al., 2006)
Sandercock et al., 2017	(Ruiz et al., 2011), (Ramírez-Vélez et al., 2015)
Schmidt et al., 2017	EUROFIT protocol.
Segura-Jiménez et al., 2016	Best of 2
Sigmundsson et al., 2017	No info
Smith et al., 2017	(Castro-Pinero, Ortega, et al., 2010), Best of 2
Tan et al., 2017	Best of 2
Tercedor et al., 2017	(Chillon et al., 2014)
Tishukaj et al., 2017	(Castro-Pinero et al., 2009)
Ubago-Guisado et al., 2017	(Castro-Pinero, Artero, et al., 2010)
Valtuena et al., 2013	(Ortega et al., 2011)
van Deutekom et al., 2013	(Ruiz et al., 2011), EUROFIT protocol. Best of 3
Vanhelst et al., 2016	(Ortega, Artero, et al., 2008), (Ortega, Ruiz, et al., 2008)
Welk et al., 2015	Best of 2. (Agostinis-Sobrinho et al., 2017)
Winwood, Accepted	Jump as far forward as possible and land on 2 feet without falling. Best of 2

Few studies adopted protocols created by other authors previously. The protocol of Ortega and colleagues of 2017 (Ortega et al., 2017) was the most adopted (8 times). Protocols proposed by Ortega but in other studies were also cited often (Ortega et al., 2015): 7 times; (Ortega et al., 2011): 6 times. The protocol of Castro-Pinero and colleagues of 2010 (Castro-Pinero, Ortega, et al., 2010) was adopted 4 times and the protocol Cadenas-Sánchez and colleagues of 2016 (Cadenas-Sánchez, Nystrom, et al., 2016) 2 times. Other less adopted protocols were not considered.

Discussion and Conclusions

The main finding of the present review is that a SOP was not created for the SLJ test but the indications given by the authors are quite the same. The SOP that the authors of the present work want to suggest is to perform the horizontal jump from a standing position with a straight torso, feet together and shoulder's width apart behind a line. The participant is free to choose when to perform the jump and the push-off has to be as far as possible with a horizontal trajectory. The swing of the arms and the bending of the knee is allowed. The landing has to be with both feet together amortizing the jump bending the knee. If the participant falls, the jump has to be repeated. The distance to use as evaluation should be the best of two trials (Table 3).

In comparison to the SOPs created on the CMJ and SJ test (Petrigna et al., 2019) in which a variety of testing protocols and devices was adopted, the indications given to the participants for the SLJ test are more consistent (table 2). As in the review on vertical jumps (Petrigna et al., 2019), the SLJ should start the test from an erect standing position with a straight torso. The upright position of the torso emphasises the use of the leg extensors (Moliner-Urdiales, Ortega, et al., 2010; Tounsi et al., 2015). The starting position should have to be with extended legs but differently from the CMJ and SJ tests were the hands where on the hips, in the SLJ test, participants can freely use the arms. As the vertical jumps, also for the horizontal jumps the feet are shoulder-width apart. The SOP for CMJ test of the review on vertical jumps (Petrigna et al., 2019) was characterized by a push-off phase with a controlled downward movement (until the knee angle reaches 90°) while in this case the participants were left to decide the entity of the movement. According to the literature (Wakai & Linthorne, 2005), there is an optimal angle that is of 19o-27o degree for the best SLJ test performance and the preferred angle of the jumpers is 31o-39o but the differences between the two horizontal jumps distance were small making not useful to monitor the degree of the knee during this phase. The toe-off, obviously, such as it was for the CMJ and SJ test has to be a maximal horizontal effort jump with a 2-feet technique, such as the landing that has to be with feet together. During landing it is important to amortize the movement to avoid the risk of injuries (Aerts et al., 2013). Differently from the review on vertical jumps (Petrigna et al., 2019) for the SLJ test, instruments to evaluate the performance are not necessary. To measure the length of the jump, for the SLJ test it is enough a meter to estimate the distance between the starting line and the point in which the heel touched the ground. Related to the number of jumps and the trials to consider, instead of the five jumps proposed in the CMJ and SJ testing procedure of the review on SOPs (Petrigna et al., 2019), the best of two jumps with one minute of passive rest is enough for the SLJ test. The same standardized warm-up proposed for the vertical jumps (Petrigna et al., 2019) can be adopted also for the SLJ test and this follows the indications of Pinfold and colleagues (Pinfold et al., 2018). The warm-up is composed of two sets where participants stand on one leg and nod the head gently for 30 seconds. This is followed by a single leg airplane squat with hip thrust and with trunk rotation, both for 20 times. They should have also to perform a single leg airplane squat with a black theraband resistance applied to the knee that includes trunk rotation with a dumbbell held in hand for 10 times, a monster walk with a black theraband resistance positioned around the forefoot, forwards and backward, and side-to-side for three meters.

A limitation was that, due to the variety of testing methods, it has been impossible to compare the results and consequently to perform a meta-analysis. A second limitation of the present review was related to the population. Indeed, adults and older adults were excluded, furthermore, gender was not considered due to the mixed samples within the studies analyzed. In the future, investigators should analyze the population according to the age and the gender.

Table 3

Standard Operating Procedures proposed for the standing long jump test (SLJ)

Phase	
Starting position	Erect position with trunk straight. Feet shoulder width apart
Push-off	Free downward movement
Toe-off	Maximal and explosive horizontal jump
Landing	Feet together
Warm-up suggested	Procedure described by Pinfold et al., 2018
Hands position	Free
Barefoot	No
Number of jumps	Best of 2
Rest time	1 minute between

In conclusion, SOPs for the SLJ test does not exist in the literature and consequently a standardized procedure was proposed for the SLJ test such as it was for the vertical jumps. In this way both, vertical and horizontal jumps present SOPs that, in everyday situations, could facilitate the evaluation of the population examined and the comparison of the results, especially in the health context.

Contribución de cada Autor: "conceptualization, L.P., A.P., and A.B.; methodology, L.P., A.P., and A.B.; analysis, L.P., A.P., and A.B.; writing, revising and editing, L.P., A.P., A.B. and M.G.L.; supervision, M.G-L.".

Financiación: "This research did not receive any external funding".

Conflicto de Intereses: "The authors declare that they have no conflict of interest".

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