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REVIEW

EXERCISE PHYSIOLOGY AND BIOMECHANICS

A scoping review on how physical fitness is evaluated in sitting volleyball players

Luca PETRIGNA [1, 2] *, Antonina PETTA [1], Valerio GIUSTINO [1], Ignazio LEALE [1], Guglielmo PILLITTERI [1], Antonio PALMA [1], Daniele ZANGLA [1], Giuseppe BATTAGLIA [1]

[1]Sports and Exercise Sciences Research Unit, Department of Psychology, Educational Science and Human Movement, University of Palermo, Palermo, Italy; [2]School of Medicine, Department of Biomedical and Biotechnological Sciences, Section of Anatomy, Histology and Movement Science, University of Catania, Catania, Italy

*Corresponding author: Luca Petrigna, School of Medicine, Department of Biomedical and Biotechnological Sciences, Section of Anatomy, Histology and Movement Science, University of Catania, Via S. Sofia 87, 95123 Catania, Italy. E-mail: luca.petrigna@unict.it

ABSTRACT

INTRODUCTION: Sitting volleyball is a widely practiced paralympic sport. A correct and standardized physical evaluation helps coaches to plan and manage the training. It is also important to evaluate physical fitness accurately and adopt standardized protocols to compare and normalize the data. The aim of the study was to evaluate physical fitness evaluation methods adopted in sitting volleyball and to eventually propose standard operating procedures.

EVIDENCE ACQUISITION: English-written and peer-reviewed original articles were included in this review. The population studied was composed only of athletes practicing sitting volleyball. Articles were searched on the electronic databases PubMed, Web of Science, and Scopus using keywords matched with Boolean operators. Two independent investigators collected and screened the studies against the eligibility criteria. Data were analyzed narratively.

EVIDENCE SYNTHESIS: Only 7 studies were eligible and included in this review, but a wide testing methodology exists. There are some tests commonly adopted in the studies included and these are the handgrip test, the agility *t*-test, the speed, and endurance test. These tests with the 2-site skinfold thickness evaluation, the modified push-ups, the shoulder-stretch test, the chest throw test and the simple reaction time task were included in the standard operating procedure.

CONCLUSIONS: The literature on the topic is poor and standardization of the testing procedure to evaluate the physical fitness of people practicing SV has been provided.

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KEY WORDS: Surgical procedures, operative; Disability evaluation; Sports.

Introduction

People with disabilities, generally, practice less physical activity if compared to people without limitations,[1-3] probably due to the physical and social barriers, and financial limitations.[4] This has negative effects on aerobic and muscular fitness that is lower than typically developing children[5] and could lead to obesity making important the control of weight and the practice of exercise in this population.[6] Fortunately, people with disabilities that practice regular physical activity present increments in the health-related physical fitness characteristics,[7-9] and functioning,[10] but also in postural balance control, muscle strength, and quality of life.[11] Improvements are also in the mood, the physical status, the social behavior and body/shape,[12] the functional status, the life satisfaction scores and quality of life.[13, 14] The highest example of adapted sport is represented by the Paralympic Games, a similar event to the Olympic Games. Paralympic Games are people with physical disabilities (amputation or limb deficiencies), nervous impairments (cerebral palsy, spinal cord-related disability), visual and intellectual impairment, or other

(disabilities not included in the previous classifications).[15] The Paralympic Games show the abilities of people with promote disability rights ensuring integration, accessibility of the built environment, and equality of opportunity.[4, 16] Furthermore, the Paralympic Games, due to the interest of the media, increase the interest of people with disabilities in sports participation, and highlight the importance of exercise as a health prevention tool.[16] One of the disciplines of the Paralympic Games, since 1980, is the sitting volleyball (SV). This sport was invented in 1956 for physically impaired people (*i.e.*, amputation, poliomyelitis, neuromuscular disease, and people with minimal disability). The practice of SV improves muscle endurance and flexibility,[17] but it has also a positive effect on everyday life, mood, physical status, social behavior, and body shape/image.[12] Similar to other paralympic sports, it is important to standardize the evaluation methods.[18] A standard operating procedure (SOP), a document that provides details of a process to allow the correct repetition of the protocol[19, 20] could help to make the testing session replicable and to normalize the data.[21] Also to consider, when the evaluation is for population-based studies or in a school settings[22] is that field tests are easier, faster, and cheaper to administer if compared with laboratory evaluation.[23] For the reasons highlighted, the objective of the study was to evaluate the test adopted in the literature to evaluate physical fitness in SV players and to propose a SOP that includes the common tests and aspects of the testing procedures.

Evidence acquisition

The manuscript followed the preferred reporting for systematic reviews and meta-analyzes for Scoping Reviews (PRISMA-ScR) checklist and explanation.[24] The manuscript was not previously recorded even if the protocol was written before the search of the papers, and it was followed step by step.

Eligibility criteria

The eligibility criteria were created for Population, intervention, comparison, outcomes, and study design (PICOS) as proposed by PRISMA. Participants included were athletes practicing SV while no limitations were adopted related to the kind of intervention (the interest of the review is around the tests adopted) and the comparison (observational studies, clinical trials, descriptive studies, randomization, and longitudinal were included) if physical fitness was evaluated. Only English-written manuscripts were included independently of the origin country while review, meta-analysis, abstract, citations, conferences abstracts, opinions, books or book reviews, letters, editorials, not peer-review manuscripts were excluded.

Search strategy

The studies were collected through screening the electronic databases PubMed (NLM), Web of Science (TS) and Scopus, and manuscripts were collected if published before June 8, 2022. Two keyword groups were created and matched adopting the Boolean operator AND and OR. The keywords terms were: 1) key words 1 included sitting volleyball and seated volleyball; and 2) key words 2 included physical fitness, sports physiology, and performance analysis. An example of matching included: sitting volleyball AND (physical fitness OR sports physiology OR performance analysis).

Record, management, and analysis of the manuscript

Two investigators performed this part while the coordinator of the study was involved if there was disagreement

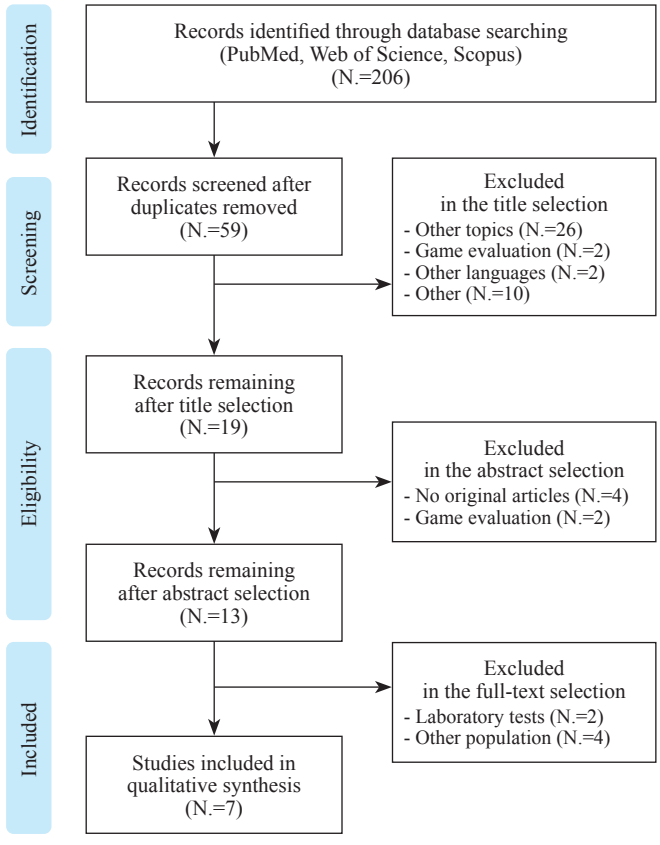

Figure 1.—Flow diagram representing selection process of manuscripts.

between the authors. The manuscripts found in the electronic databases were screened to find duplicates, and against inclusion and exclusion criteria. In the first step of the process, the screening was performed on the title, in the second step using the abstract and in the last step, the full text was examined. A Microsoft Excel (Microsoft Corp, Redmond, WA, USA) spreadsheet was created to collect information related to the manuscript; year of publication, sample size, sample age, gender, objective of the study, test adopted to evaluate health-related physical fitness components (cardiorespiratory endurance, muscular strength, flexibility, and body composition), and the skill-related components (agility, postural balance, coordination, power, reaction-time, and speed) as classified by Caspersen *et al.*[25] Data were descriptively analyzed and discussed with narrative synthesis.

Evidence synthesis

A total of 206 manuscripts were detected, 83 were double, 4 were excluded because not original articles; 36 were excluded because they analyzed a different topic; 4 were about game evaluation and 2 adopted laboratory test; 2 because it was written in another language; 1 because it was not evaluated physical fitness; 9 for other reason. A total of 7 manuscripts were finally included. The PRISMA diagram flow synthetizes the manuscript selection process (Figure 1). A total of 196 people (45 males and 33 females; 118 not specified) were involved. Three studies had not reported the gender of their participants. The mean age was 31.4 years and in 6 studies. One study had not reported the age of their sample. They were elite or national level athletes. More information is provided in Table I.[17, 26-31]

Physical fitness evaluation methods

Information related to physical fitness characteristics of the included studies are summarized in Table II.[17, 26-31] From the protocols adopted by the authors, a SOP has been proposed. It is composed of the two-points skinfold test (calf and triceps) to evaluate body composition; the back-scratch test to evaluate flexibility; the handgrip test to evaluate muscle strength and the modified push-ups test to evaluate muscle endurance; the speed and endurance test to evaluate cardiorespiratory endurance and speed, the modified agility *t*-test for agility and coordination; the

TABLE I.—*General information related to the studies (N.=7) included in the review.*

Author, year	Objective	Number [f] (m)	Age (years) (SD)	Level
Ahmadi *et al.*[26]	Present the profile of physical performance tests and compare men and women	15 [8] (7)	31.6 (7.2)	National team
Ahmadi *et al.*[27]	Examine the relationships between HG and isokinetic strength	12 [6] (6)	31.4 (6.5)	National team
Bratovcic *et al.*[28]	Examine the morphological-motor status of top-quality sitting volleyball players	63		Elite
Jeoung *et al.*[29]	Evaluate the relationship between performance and fitness of SV players.	45	42.5 (7.4)	Elite
Marszalek *et al.*[30]	Evaluate relationships between anaerobic performance, field tests, game performance and anthropometric variables of SV players	20 [8] (12)	33 (9.3)	Elite
Wong *et al.*[17]	Examine the effect of sitting light volleyball in improving physical fitness	19 [11] (8)	18.5 (3.2)	Students
Yüksel *et al.*[31]	Determine the physical profiles of SV players	(12)	31.4 (6.7)	National team

F: female; M: male; SD: standard deviation; SV: sitting volleyball.

TABLE II.—*Information related to physical fitness characteristics of the included studies (N.=7).*

Author, year	Muscle force	Flexibility	Skill-related components	Body composition
Ahmadi *et al.*[26]	HG; throw test		SAT; SET; MAT	
Ahmadi *et al.*[27]	HG			
Bratovcic *et al.*[28]	HG; throw test; push-up; body lifting	Bend on box Flex with bat Knuckle in height	SET; Japan test; Plate tapping test	
Jeoung *et al.*[29]	HG; throw test	Back scratch test	SAT; SET; MAT	
Marszalek *et al.*[30]	Throw test		SAT; SET; MAT	
Wong *et al.*[17]	HG; dumbbell press	Back scratch test		Skinfold test
Yüksel *et al.*[31]	HG; sit-up (m); abdominal endurance (m); push-up (m)	Back scratch test	Modified functional reaching test	

HG: handgrip; m: modified; SAT: Speed and Agility Test; SET: Speed and Endurance Test; MAT: Modified Agility *t*-test.

TABLE III.—*Standard operating procedure for the evaluation of physical fitness of sitting volleyball players.*

Physical fitness component	Test adopted
Body composition	Two-site skinfold thickness
Muscular strength and endurance	Handgrip evaluation Modified push-ups
Flexibility	Shoulder-stretch test
Speed and endurance	Speed and Endurance Test
Agility and coordination	Modified Agility t-test
Power	Chest throw test
Reaction time	Simple reaction time task

chest throw test for power evaluation; and the simple reaction time task for reaction time (Table III).[17, 26-31] Analyzing the SOP test by test, body composition was evaluated only by Wong *et al.*[17] through the skinfold test. The decision to propose the two-point skinfold evaluation for body composition is because it is simple to administer,[32] cheap, valid, and accurate field evaluation.[33] Furthermore, it has been proposed the two-points because in this way the test is faster and easier to administer if compare with the seven-point skinfold evaluation. Muscle strength was mainly evaluated through the handgrip test by different studies.[17, 26-29, 31] The indication for the handgrip test provided by Ahmadi *et al.* in both studies included[26, 27] were to squeeze as hard as possible the instrument for 3 seconds. Ahmadi *et al.*[26] used the best result of two attempts. As Wong *et al.*[17] the authors also separated the trials by a rest time of about 2 to 5 seconds.[34] Ahmadi *et al.*[27] used the highest value of 3 attempts with 15-20 second rest as suggested by a previous study,[35] such as the procedure that they followed: elbow at 90° of flexion, arm in a neutral position and not in touch with the trunk. Arms straight and not in touch in the body was used by Yuksel *et al.*[31] Consequently, the evaluation of muscle strength should be performed through the handgrip evaluation because this test is valid and reliable[22, 36] but also because it is a long-term predictor of mortality from chronic and cardiovascular diseases.[37, 38] Importantly, the handgrip test provides information related to defense and receive of SV players.[29] Another evaluation for muscle strength is the throw test. The protocol adopted for this evaluation of Ahmadi *et al.*[26] and Marszalek *et al.*[30] is the one proposed before by Molik *et al.*[39] and Harris *et al.*[40] in which the athletes were seated on the floor with extended legs, feet 60 cm apart and the back against a wall and the medicine ball (4 kg for men and 2 kg for women) had to be throw as far straight forward with both hands from the chest while their back was maintained against the wall. Participants were allowed two attempts only and the best thrown distance was recorded. Bratovcic *et al.* asked the participants to throw a 1.5 kg medicine ball from a lying position.[28] Jeoung[29] required also to perform a one hand side throw, and overhand throw. To evaluate strength and endurance, Wong *et al.*[17] adopted the Dumbbell press: from a sitting position participants had to lift a 5-pound dumbbell as many times as possible.[41] Yuksel *et al.*[31] adopted the Modified Sit-up Test: from lying on the back, knees bent, soles of the feet fully on the mat, hands on each side of the hips, and fingers in extension on the mat, participants had to arise until the scapula bottom level for 30 s; the modified abdominal endurance: from a lying on the back, participants had to arise until scapula bottom level and keep this position as much as they could; the modified push up test: face down participants performed the version for the females. Muscle strength and endurance were also evaluated through push-ups on and body lifting in 30 s.[28] Consequently, the modified push-ups are a test for the evaluation of dynamic strength of the upper body but also is an indicator of different health outcomes such as perceived health, mobility, and disability.[42] This test presents reliability and a small test-retest variation[43] and it is in the Brockport Physical Fitness test manual[41] making it ideal also for physically impaired people. It is important to practice before the test performance because it has been noted a learning effect.[43] Related to the evaluation of muscle power, it was decided to propose the chest pass test because it provides information about the upper body, abdomen, and waist, and it is correlated to attack, block, and serve[29] and receiving[30] of SV players. Muscle flexibility was evaluated with different tests. Yuksel *et al.*,[31] Jeoung,[29] and Wong *et al.*[17] adopted a similar protocol for flexibility, the so-called Back Scratch Test, or the shoulder stretch test, respectively. It was measured, in a sitting position and back vertical, the distance (cm) in between the 2nd fingers of the two hands placed behind the back (if the fingers were in contact the value was 0), with one arm reached over the shoulder and with another one down the back. Other tests adopted were the bend on a box, flex with bat, and knuckle in height.[28] Consequently. the back scratch test was proposed to evaluate flexibility of the upper limbs in people with disability because is a test included in the Brockport Physical Fitness test manual.[41] Ahmadi *et al.*[26] and Jeoung[29] adopted the Speed and Agility Test using the protocol of Marszalek *et al.*[30] During the test, participants had to complete a pathway signaled with cones as quickly as possible and the best time of the two trials was adopted. Ahmadi *et al.*[26] and Jeoung[29] used again the protocol of Marszalek *et al.*[30] also

for the Speed and Endurance Test: the best time of two trials of a test composed of cones that had to be touched by the participants was recorded. A speed endurance[28] was also adopted but no information is provided about the protocol. The speed and endurance tests were chosen in the SOP because is useful for the determination of endurance and speed[30] but also because is related to the attack, block and serve capacity of SV players.[29] For the Modified Agility t-test, authors[26, 29, 30] adopted the protocol of Sassi *et al.*[44] It was also adopted the Japan test.[28] To measure the arm's move speed it was used the plate tapping test (two plastic discs had to be touched as fast as possible).[28] The t-test is a valid evaluation for agility and coordination, leg power and speed and it is also reliable[45] as the modified version of this test.[44] Furthermore, this test is ideal to obtain information related to the defense and receive capacities of SV players.[29] To evaluate the reaction time, it could be adopted a simple reaction time task where participants must respond, verbally, to auditory stimuli randomly administered at different times in-between.[46] The decision to include these tests that interest especially the upper limbs are due to the sports characteristics. Indeed, the players move on the court using their hands while the buttocks must remain on the floor during the game. Finally, Wong *et al.*[17] adopted the Brockport physical fitness test.[41]

Limitations of the study

The study has an important limitation related to the sample that is composed of different levels of athletes with different physical characteristics making impossible the comparison of the results. A second important limitation is related to the methodology adopted that is different between the studies, indeed, it has been impossible to perform a systematic review and a meta-analysis.

Conclusions

The review highlights how little research has been conducted on SV. From the study also emerged a wide variety of testing methodologies adopted to evaluate the same physical fitness characteristics even if some tests were proposed by more authors. From the common tests of the study included a SOP was created and proposed (Table III)[17, 26-31] to standardize the physical fitness test procedure for SV players. Future studies should have to evaluate the physical fitness characteristics of SV athletes adopting the proposed SOP, also to create normative data, a useful tool to evaluate the level of the team. Future research should have to consider this topic carefully.

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