Asian J Sports Med. 2020 March; 11(1):e98225. doi: 10.5812/asjsm.98225.

Published online 2020 February 18. **Research Article**

Effects of Sitting Light Volleyball Intervention on Physical Fitness Among Hong Kong Students with Physical Disabilities: A Pilot Quasi-Experimental Study

Ming Yu Claudia Wong [1,*] and Ka Man Leung [2]

[1] Hong Kong Baptist University, Hong Kong, China
[2] The Education University of Hong Kong, Hong Kong, China

[*] *Corresponding author*: Hong Kong Baptist University, Hong Kong, China. Email: 18481795@life.hkbu.edu.hk

Received 2019 September 19; **Revised** 2020 January 13; **Accepted** 2020 January 19.

Abstract

Background: Hong Kong students with physical disabilities were being seen as physically inactive compared with typically developed people or even people with other disabilities, such as visual impairment or intellectual disabilities. Lack of regular physical activity would lead to poor physical fitness, and yet is associated with a higher risk of being obese or other physical as well as mental health problems. Currently, a newly developed sport, sitting light volleyball, modified from the Paralympic sitting volleyball, is considered as suitable for disabled people with lower physical fitness, in which was able to increase fitness level and increase their physical activity.
Objectives: The current study aimed to examine the effect of sitting light volleyball in improving physical fitness among students with physical disabilities in Hong Kong.
Methods: The current study was an interventional, quasi-experimental study. Nineteen participants, 8 males and 11 females, with the age of 18.5 on average (SD = 3.24), participated in the study. Two local special education schools were involved in the 10-week (65 minutes per session) sitting light volleyball intervention program. Participants took part in a fitness test before and after the intervention. The intended-to-treat approach was adopted throughout the data analysis, with the last observation carried forward method for managing the missing data.
Results: No significant changes in body composition outcomes of the participants were found. The non-parametric sign test showed significant median differences on dumbbell press test and flexibility test of the right shoulder before and after the intervention, with Z = 2.94, P = 0.003; Z = 2.20, P = 0.028, respectively.
Conclusions: This indicated that the sitting light volleyball intervention was able to provide preliminary evidence on showing the enhancement of muscle endurance and flexibility of the students with physical disabilities. Whereas, intensified interventions should be done in the future to examine the possible changes in body composition as well as psychological health conditions.

Keywords: Physical Disability, Sitting Light Volleyball, Physical Fitness

1. Background

Children with disabilities, being a minority in the society, their level of physical activity and fitness was lacking concern, either by the disabilities themselves or society. Government statistics, in the year of 2014 - 2015, has revealed that within the almost 900 leisure-time physical activity programmes or fun-day organized or co-organized by the Government of the Hong Kong Special Administrative Region (HKSAR) Leisure and Cultural Services Department, only 13 of them were with people with physical disabilities; while only 2 were for children with special needs, which include any kind of disabilities (1). Researchers found out that children with physical disabilities spent most of their time, either at school or at home, and only tend to be more engaged in walking during free time (2); thus being seen as physically inactive (3, 4). Importantly, a disabled person with inadequate physical fitness would have a higher risk of developing cardiovascular diseases and metabolic syndromes, such as heart disease, diabetes, stroke or other health problems (5, 6); as well as being obese and suffering from mental health issues (7-12). And yet, children and adolescents with any form of disabilities were more likely to be inactive and had poorer physical fitness than typically developed children (13). The Dutch's physical activity report card on youth with disabil-

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ities reported that only 26% of the physically disabled children in special education school did participate in sports regularly compared to over 70% in non-disabled youth (14). Therefore, the low level of physical activity engagement and fitness of children with disabilities were associated with inferior health status, in both physical and mental health (4, 15). It can be known that there were various factors leading to the lack of physical activity and poor fitness of children and adolescents with disabilities; for instance, lack of assistance from caregivers, lack of physical activity (PA) opportunities, concern for the children's safety, lack of professional teacher training, insufficient facilities at school for disabilities or other socio-environmental factors (16).

Schools are considered as an essential setting for students' health-promotion and education (4, 9, 17). Local research has also proved that the active behaviour of children with disabilities was being more encouraged under structured activities with teachers' supervision (2). However, the HKSAR government-commissioned consultancy study (1) demonstrated that the physical activity participation opportunities for children with disabilities varied from school to school. Hong Kong research has only indicated significant results in the physical fitness-and-activity intensity relationships within children with intellectual disability and social development problems but not children with physical disabilities (PD) (4). Schools for physical disabilities showed concern towards the decrease in sports courses' variety and availability offered by related organizations specialized for them (1); which may result in further physical inactivity and physical health issues within children with physical disabilities (18). Therefore, it is critical to provide more PA opportunities to people with physical disabilities.

1.1. Sitting Light Volleyball

Among different types of physical activity, light volleyball was found to enhance older adults' physical and psychological health (19). The light volleyball ball is around 20 cm bigger in circumference and 100 g lighter in weight than that of traditional volleyball; thus it enables travel in the air at a lower velocity and for a longer time. The development of light volleyball was aimed at providing another choice of sport for people with lower fitness levels, and to reduce fitness-related degradation and increase their physical activity. Going further, Leung and her colleague were also being funded to develop and promote sitting light volleyball among adults with physical disabilities.

Sitting volleyball is a commonly known Paralympic Sport modified from traditional volleyball to suit athletes who are disabled physically (20, 21). Despite sitting volleyball allowing players to be at a seated position in which the pelvis must contact the ground during the game, the volleyball used is seen to be unpredictable (20) and even faster than that of Olympic traditional volleyball (The British Paralympic Association, 2014), in which players with lower fitness level and sport competence are less able to access. Hence, the combination of sitting volleyball and light volleyball may be considered as an appropriate physical activity for people with physical disabilities (PWPD) as a leisure activity.

In 2018, the current research investigator (Leung KM) and her colleague (Chung PK), successfully obtained a Knowledge Transfer Partnership Seed Fund to (1) develop a new sport, sitting light volleyball (SLVB); (2) investigate the impact of a sitting light volleyball intervention on improving health among PWPD, and (3) promote SLVB by organizing SLVB classes. We pilot tested SLVB with PWPD and examined its game characteristics, rules, and regulations. SLVB was then developed using sitting volleyball from the Paralympic games as a reference. Additionally, four focus group interviews were conducted to investigate PWPD's experiences and opinions related to SLVB. Generally, these interviews demonstrated a positive perception of playing SLVB among PWPD in HK (22). Using structural equation modelling, three themes emerged when playing SLVB at individual, and interpersonal levels. These themes included "increased perceived competence in PA", "increased PA enjoyment", and "increased social support and communication". Next, the SLVB intervention resulted in significant improvements in cardiovascular endurance, body composition, PA enjoyment, and quality of life among participants in the SLVB group compared to the control group (Leung et al., 2019, unpublished work).

Hence, in correspondence with the needs of the students with physical disabilities stated by the government consultancy study and the positive findings of our pilot study in adults with physical disabilities, sitting light volleyball was then applied and the first place to study its health impact was on students in special education schools in Hong Kong.

2. Objectives

The aim of the research was to examine the effect of the sitting light volleyball intervention in improving physical fitness among students with physical disabilities. Since no research has been done on applying sitting light volleyball on students with physical disabilities, the null hypothesis expects that the sitting light volleyball intervention can

generate no significant effect on the physical fitness of students with physical disabilities, neither body composition nor musculoskeletal functioning.

3. Methods

The present pilot study was a single group quasi-experimental intervention study, taken place in two (out of seven) special education schools for students with physical disability in Hong Kong.

3.1. Participants

There were only a total of seven special education schools for children with physical disabilities in Hong Kong, and due to the tight teaching schedules of students in these schools; the convenient sampling method was adopted. Eventually, only two of the schools accepted the invitation and agreed to participate in our study. The inclusion criteria of participants included: (a) school students in Hong Kong special schools serving PWPDs; (b) registered PWD in Central Registry for Rehabilitation; (c) with at least one functional arm; and (d) cognitively understand the intervention program instruction. Students who (a) had a history of cardiovascular disease that hinders study participation; (b) had seeing and hearing difficulties; and (c) were not approved by his/her physician to participate in the study due to a limiting medical condition, were excluded from the study.

In this research, 19 students, including 8 males and 11 females with the age of 18.5 on average (SD = 3.24), participated in the study. Eighteen of them were in the pre-test and the intervention, while 7 of them did not get involved in the post-test, yet 1 of them was absent from the pre-test but still involved in the intervention programme as well as the post-test. The disability conditions of the subjects were mainly loss or deformity of limbs and muscular dystrophy; from which five of them were wheelchair users.

3.2. Design and Measures

3.2.1. Procedures and Sitting Light Volleyball Intervention

The subjects were expected to be involved in the fitness test held before and after the intervention program, and they were briefed on the fitness test procedures before each test. The consent form was given to their parents in advance for endorsement. The parents were told about the process of intervention and the purpose of the current study, as well as the confidentiality of the data collected. The parents and students were also reminded that they would be allowed to withdraw from the research at any time without any penalty and without loss of benefits.

The intervention programme was carried out from November 2018 to January 2019 by two qualified registered coaches and one assistant coach from the Light Volleyball Association of Hong Kong. The program consisted of 10 sessions, with 1 session per week and 65 minutes per session. Each session involved a warm-up, sitting light volleyball skills training (supplementary file Appendix 1), and match play then finished with cool-down and stretching (23). The duration of the intervention was planned to in line with the recommended guidelines of U.S. Department of Health and Human Services Centers for Medicare and Medicaid Services (2003) of 2 sessions per week and 90 minutes per session (24); however, in considering the physical status of disabled students as well as the fixed time period of the schools' physical education lesson, the intervention frequency and duration were being restricted. The intervention program was designed by the second author, a physical education specialist who first developed and promoted light volleyball and sitting light volleyball in Hong Kong, and she is a former player in the Hong Kong National Volleyball Team as well.

3.2.2. Fitness Test Measurement

The Brockport physical fitness test (BPFT) was used to measure the participant's fitness level in this study. It is a criterion-referenced test of fitness, which the included items and the respected standards that were established through research findings, norms-referenced data and expert opinions were used to see whether the values were seen to be significant for the individual's health. Another reason for utilizing this measurement is that the test manual consists of a key element of providing physical fitness test standards especially for youngsters with disabilities of age 10 or above (25). The fitness tests used in this study included: body mass index (including weight and height), skinfold test (body composition), handgrip test, dumbbell press (5 pounds, muscular endurance) and shoulder scratch (flexibility) test.

3.2.3. Body Composition

Participants' body composition were examined by the body mass index (BMI) by using the body composition analyzer - TANITA (model MC 780 MA). By using the TANITA, the analyzer provided assessment results other than weight and BMI, such as predicted muscle mass (PMM), fat mass (FM), as well as skeletal muscle index (SMI). SMI is the ratio of the muscles in the arms and legs to the height (26). The skeletal muscle index (SMI) is also considered as worth reporting within the physical disability students' population. The skeletal muscle index is able to identify possible loss in muscle mass. This condition can also be called as

sarcopenia, and the ideal SMI is ranged from 5.67 to 7.23. Actually, this condition is usually reflected on the ageing population, however concerning the participants of the current study is students with physical disabilities that, functional impairment and physical disability tended to show a significant association with low skeletal muscle mass (27, 28). Nevertheless, it is worth noting that some of the participants were using wheelchairs so they were not able to stand on the TANITA, body composition analyses reports were not possible to generate, thus leading to the missing values in weight and BMI. But still, their height was measured by soft tape with participants at a lied down position on an exercise mat. By the same token, the skinfold test (triceps) was applied to all participants for measuring the level of estimated body fat, using the skinfold caliper (25).

3.2.4. Musculoskeletal Functioning

Musculoskeletal functioning in this study included muscle strength and muscle endurance (29). First, the handgrip test was used to measure the maximum muscle strength (in kg) of individuals. The subjects were told to grip the handle of the dynamometer and squeeze it with maximum strength. Participants performed two tries for both hands and rest time was given in between them (20, 25). Secondly, the dumbbell press was conducted to examine the strength and endurance of one's arms and shoulders. Participants were asked to sit still, either in a wheelchair or a stable chair, and to lift a 5-pound dumbbell as many times as possible. The whole process was served by a physical education student helper for safety considerations (25). Both hands were measured with only one attempt.

3.2.5. Flexibility

Finally, a shoulder stretch test was used to assess the upper-body flexibility of the participants. The test was to measure the distance (cm) in between the fingertips of two hands placed behind the back, with one arm reached over the shoulder and with another one down the back. The test measured both hands entitled "right" or "left" on the basis of the arm reaching over the shoulder (25).

3.3. Limitations

A limitation we would have to point out is that, all students who participated were recommended and approved by the school teacher and the occupational therapist of the school. Therefore, this operation may reduce the reliability and validity of the research due to the non-randomized sample. Despite that, researchers think that it is acceptable as it would be considered as more ethical for students with physical disabilities and to avoid possible risks of activity injuries.

3.4. Statistical Analysis Method

The IBM SPSS Statistics 25 was used to carry out all statistical analysis. The current study was an experimental intervention research, a more conservative approach, intention to treat (ITT) analysis was adopted so that the data were analyzed according to the preliminary arrangement, regardless of what the subject actually received or other comorbidities that the subjects have engaged in. Also, the last observation carried forward (LOCF) method (29), was used to manage the missing data. Descriptive statistics were also used to indicate the demographic information and the body composition results of the participants. While, due to the small sample size, the nonparametric Wilcoxon signed rank test was used to analyse the one-group pretest-posttest differences.

4. Results

4.1. Descriptive Statistics

A total of 18 subjects were included in the statistical analysis, excluded one subject who did not complete the pre-test. Among the 18 subjects, (5 from school A and 13 from school B), there were 8 males and 10 females, with over half of them aged between 16 - 20 and the average age at 18.6 years old (Table 1). Overviewing the body composition status of all the subjects, the participants were equipped with healthy body composition (i.e., BMI ranged between the fifth and 85th percentile (30), with the average BMI at 20.43 (SD = 3.77), which is considered as within the healthy weight range (31). Additionally, the SMI of the participants were all above the desirable range, with mean at around 6.9 (Table 2).

4.2. Body Composition

Regarding the pretest-posttest differences on aspects of body composition, the Wilcoxon signed rank test did not reveal any significant results on all related aspects, including BMI, skinfold test (triceps), fat mass (FM) and predicted muscle mass (PMM). But still, the descriptive statistics showed a slight increase in the overall mean of the BMI, FM and SMI (27, 28). Therefore, whether a longer intervention program is able to reveal a positive body composition change among students with physical disability is still considered as uncertain (Table 2).

4.3. Musculoskeletal Functioning and Flexibility

Apart from the descriptive means demonstrate in Table 3, the pre-test and post-test differences on the handgrip test, dumbbell press and shoulder stretch test were shown by the statistical results generated from the nonparametric Paired *t*-test, Wilcoxon signed rank test. The results showed that the median of the post-test of both dumbbell press test (dominant and non-dominant hands) was significantly higher than that in pre-test, with Z = 2.94, P = 0.003; Z = 2.82, P = 0.005. While, the flexibility of the right hand also showed a significant median improvement on the post-test, with Z = 2.20, P = 0.028. The Wilcoxon signed rank test thus demonstrated that the subjects have shown significant improvements in muscle endurance as well as flexibility.

Table 1. Descriptive Statistics

	Values[a]
Gender	
Male	8 (44.4)
Female	10 (55.6)
Total	18 (100.0)
Age	
10 - 15	2 (11.1)
16 - 20	10 (55.6)
20 - 25	4 (22.2)
Total	18.56 ± 3.24

[a]Values are expressed as No. (%) or mean ± SD.

Table 2. Descriptive Statistics for Body Composition (N = 13)

Aspects	Mean ± SD
Weight	
Pretest	48.71 ± 10.99
Posttest	49.12 ± 11.02
BMI	
Pretest	20.43 ± 3.77
Posttest	20.63 ± 3.72
FM	
Pretest	11.78 ± 6.83
Posttest	12.71 ± 6.23
PMM	
Pretest	35.02 ± 8.39
Posttest	34.53 ± 7.19
SMI	
Pretest	6.89 ± 0.90
Posttest	6.98 ± 0.99

Table 3. Descriptive statistics for musculoskeletal functioning and flexibility

Aspects	Mean ± SD
Handgrip-D	
Pretest	15.51 ± 11.08
Posttest	15.23 ± 10.19
Dumbbell press-D	
Pretest	16.94 ± 13.51
Posttest	35.06 ± 18.23
Flexibility-D	
Pretest	-12.18 ± 21.88
Posttest	-15.93 ± 20.38
Handgrip-nonD	
Pretest	14.51 ± 11.03
Posttest	14.63 ± 9.81
Dumbbell press-nonD	
Pretest	15.39 ± 16.15
Posttest	33.11 ± 18.31
Flexibility-nonD	
Pretest	-10.43 ± 21.10
Posttest	-15.92 ± 20.38

Abbreviations: D, dominant hand; nonD, non-dominant hand; SD, standard deviation.

5. Discussion

To conclude, the current 10-week sitting light volleyball intervention program applied on students with physical disabilities, is aimed at examining its effect in improving their physical fitness based on the Brockport physical fitness test (BPFT) measurement. The intervention program showed no significant effect on the aspects of body composition but did show significant improvement in muscle endurance (using dumbbell press test) and flexibility (using shoulder stretch test).

First, it is acceptable that there were less likelihood to have a significant differences on that of BMI and muscle mass (body composition), as it was seen as difficult to have a notable change after a short duration of intervention (i.e., 10-week); in addition, the intervention has only consisted of one session per week (32). Simultaneously, the energy demand of playing volleyball is being categorized as aerobic, in which it requires the usage of large muscle groups and maintained continuously for at least 20 minutes (33). We, therefore, expected the changes in body composition may become significant when we extend the intervention duration and dosage in the future. More than that, there were still inconsistent outcomes in the literature regarding whether aerobic exercise or resistance training is more effective in reducing and maintaining body weight (34). Research indicated that aerobic-only exercise group and aerobic-resistance exercise group significantly reduce obese adults' body weight and fat mass,

but not in the resistance-only exercise group. In contrast, exercise groups with resistance exercises showed a greater change in lean body mass compared to aerobic exercise (35). Other than the type of exercises, weight compensation for aerobic exercise training is also another possible factor affecting the effectiveness of weight loss. The research highlighted that it was possible to achieve significant weight loss with high volume aerobic exercise training under caloric restriction (36). It is because participants would easily increase their energy and fat intake (37) after aerobic exercise training; while it has been concluded that dietary compensation and low aerobic exercise dose have limited the expected weight loss from aerobic exercise training.

Research has also revealed that aerobic endurance training tended to have a larger percentage of improvement on upper-body muscle endurance compared with that of muscle strength (38). In line with the context of the intervention program, participants were mainly engaged in a continuous practice with less high-intensity anaerobic acts; therefore, it can explain the outcomes that the subjects have demonstrated significant differences in muscles endurance rather than in muscle strength.

On the other hand, the program participants only showed significant differences in the flexibility of the right hand. It can be interpreted that the majority of the subjects' dominant hands are right hand, in which they tended to use their right hand to hit the ball while the left hand was used to maintain their body balance; therefore, with a higher frequency of reaching out their dominant hand, the flexibility of the right hand tends to be improved. Moreover, concerning that a cool-down session was included after each lesson, that stretching was shown to be effective in improving the flexibility of volleyball players (39). In addition to that, most of the physical performance-related research only showed the improvement of disabled elderlies' flexibility in stretching and balancing exercises, like yoga and vibration exercise, as well as in resistance training (40-42). Despite having mentioned that both elderly and physically disabled have a relatively weak skeletal muscle mass compared to others, in which may have similar physical movement limitations (27, 28), the current research discovered that aerobic exercises could improve the flexibility of physical disabilities.

Furthermore, in an informal survey conducted during the data collection, most of the participants also expressed their enjoyment and positive feelings towards being physically active and did think that engaging in physical activity enables them to reduce stress or negative emotions. Hence, other than measuring the change in physical fitness objectively, an extensive intervention program with follow-up testing can be done to measure the effect of SLVB in motivating physical disability students to be more physically active, then to increase their physical activity level as well as their psychological health. In fact, children with non-motor disabilities in Hong Kong, like intellectual disability and visual impairment, were given more opportunities to engage in sports activity compared with those with physical (or called as motor) disabilities. Yet, this is due to the facilities available within schools, the accessibility towards public venues from schools, manpower as well as the type of disability of the students, would hinder physically disabled students in engaging in organized physical activities. Therefore, with the statistical support for the effect of SLVB, it will be worthwhile to have SLVB to be promoted to all the special education schools in Hong Kong.

5.1. Limitations

Whereas, the small sample size, with only two special education schools involved, has increased the difficulty of the study to determine the significant effectiveness of sitting light volleyball in improving the physical fitness of students with physical disabilities. Also, being a quasi-experimental research, without a control group, is also a concern that made the interventional effects less comparable; as well as reduced the prominent aspects of the intervention. Besides, the duration and sessions of the program are other concerning issues. It is essential to consider that the physical condition of students in the special education school might quite vary and that a longer duration or more sessions may lead to serious fatigue for students with a poorer physical condition. Additionally, it is noteworthy that some of the subjects within the current study are athletes with disabilities or even para-athletes. Hence, their professional athlete training was considered as a confounding variable of the intervention effect; and yet, it is also a limitation of having the intended-to-treat approach. However, significant pretest-posttest differences in two of the physical fitness test items could still conclude that this pilot intervention study does provide preliminary evidence that sitting light volleyball has a potential effect on enhancing the physical fitness of students with physical disabilities, thus the intervention scale should be enlarged for future implication.

Supplementary Material

Supplementary material(s) is available here [To read supplementary materials, please refer to the journal website and open PDF/HTML].

Footnotes

Authors' Contribution: Data collection, data analysis, interpretation of data and drafting manuscript: Ming Yu Claudia Wong; study concept and design as well as critical revision of the manuscript for important intellectual content: Ka Man Leung.

Conflict of Interests: The authors have no conflict of interest to declare.

Ethical Approval: The grant offered by the Knowledge Transfer Office passed through an ethics approval from the Ethics Committee of the Hong Kong Baptist University.

Funding/Support: This work was supported by the Knowledge Transfer Office, Hong Kong Baptist University; under grant (KTP/055/sept2017).

Patient Consent: The subjects were expected to be involved in the fitness test held before and after the intervention program, and they were briefed on the fitness test procedures before each test. The consent form was given to their parents in advance for endorsement. The parents were told about the process of intervention and the purpose of the current study, as well as the confidentiality of the data collected. The parents and students were also reminded that they would be allowed to withdraw from the research at any time without any penalty and without loss of benefits.

References

1. The Home Affairs Bureau - SAR Government of Hong Kong. *A consultancy study on sport for people with disabilities in Hong Kong*. 2016.
2. Sit CHP, McKenzie TL, Cerin E, McManus A, Lian J. Physical activity for children in special school environment. *Hong Kong Med J*. 2013;**19**(3):S42–4.
3. Li R, Sit CHP, Yu JJ, Sum RKW, Wong SHS, Cheng KCC, et al. Children with physical disabilities at school and home: Physical activity and contextual characteristics. *Int J Environ Res Public Health*. 2016;**14**(7):687. doi: 10.3390/ijerph14070687. [PubMed: 28672833]. [PubMed Central: PMC5551125].
4. Sit CH, McKenzie TL, Cerin E, Chow BC, Huang WY, Yu J. Physical activity and sedentary time among children with disabilities at school. *Med Sci Sports Exerc*. 2017;**49**(2):292–7. doi: 10.1249/MSS.0000000000001097. [PubMed: 28092643].
5. Andersen LB, Sardinha LB, Froberg K, Riddoch CJ, Page AS, Anderssen SA. Fitness, fatness and clustering of cardiovascular risk factors in children from Denmark, Estonia and Portugal: The European Youth Heart Study. *Int J Pediatr Obes*. 2008;**3 Suppl 1**:58–66. doi: 10.1080/17477160801896366. [PubMed: 18278634].
6. Jago R, Drews KL, McMurray RG, Thompson D, Volpe SL, Moe EL, et al. Fatness, fitness, and cardiometabolic risk factors among sixth-grade youth. *Med Sci Sports Exerc*. 2010;**42**(8):1502–10. doi: 10.1249/MSS.0b013e3181d322c4. [PubMed: 20139783]. [PubMed Central: PMC2921216].
7. Moreira C, Santos R, de Farias Junior JC, Vale S, Santos PC, Soares-Miranda L, et al. Metabolic risk factors, physical activity and physical fitness in Azorean adolescents: A cross-sectional study. *BMC Public Health*. 2011;**11**(1):214. doi: 10.1186/1471-2458-11-214. [PubMed: 21470414]. [PubMed Central: PMC3090347].
8. Ortega FB, Labayen I, Ruiz JR, Kurvinen E, Loit HM, Harro J, et al. Improvements in fitness reduce the risk of becoming overweight across puberty. *Med Sci Sports Exerc*. 2011;**43**(10):1891–7. doi: 10.1249/MSS.0b013e3182190d71. [PubMed: 21407124].
9. World Health Organization. *School policy framework: Implementation of the WHO global strategy on diet, physical activity and health*. Geneva, Switzerland: WHO; 2008.
10. Hartman E, Smith J, Westendorp M, Visscher C. Development of physical fitness in children with intellectual disabilities. *J Intellect Disabil Res*. 2015;**59**(5):439–49. doi: 10.1111/jir.12142. [PubMed: 24953003].
11. World Health Organization. *Health and development through physical activity and sport*. WHO; 2003.
12. Sit CH, Lau CH, Vertinsky P. Physical activity and self-perceptions among Hong Kong Chinese with an acquired physical disability. *Adapt Phys Activ Q*. 2009;**26**(4):321–35. doi: 10.1123/apaq.26.4.321. [PubMed: 19893070].
13. O'Brien TD, Noyes J, Spencer LH, Kubis HP, Hastings RP, Whitaker R. Systematic review of physical activity and exercise interventions to improve health, fitness and well-being of children and young people who use wheelchairs. *BMJ Open Sport Exerc Med*. 2016;**2**(1). e000109. doi: 10.1136/bmjsem-2016-000109. [PubMed: 27900176]. [PubMed Central: PMC5125427].
14. Burghard M, de Jong N, Vlieger S, Takken T. The physical activity report card + on Dutch youth with a chronic condition or disability. *Utrecht*. 2017;**1**:25–30.
15. Buffart LM, Roebroeck ME, Rol M, Stam HJ, van den Berg-Emons RJ; Transition Research Group South-West Netherlands. Triad of physical activity, aerobic fitness and obesity in adolescents and young adults with myelomeningocele. *J Rehabil Med*. 2008;**40**(1):70–5. doi: 10.2340/16501977-0135. [PubMed: 18176740].
16. Bloemen MA, Backx FJ, Takken T, Wittink H, Benner J, Mollema J, et al. Factors associated with physical activity in children and adolescents with a physical disability: A systematic review. *Dev Med Child Neurol*. 2015;**57**(2):137–48. doi: 10.1111/dmcn.12624. [PubMed: 25403649].
17. Pate RR, Davis MG, Robinson TN, Stone EJ, McKenzie TL, Young JC, et al. Promoting physical activity in children and youth: A leadership role for schools: A scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. *Circulation*. 2006;**114**(11):1214–24. doi: 10.1161/CIRCULATIONAHA.106.177052. [PubMed: 16908770].
18. Liou TH, Pi-Sunyer FX, Laferrere B. Physical disability and obesity. *Nutr Rev*. 2005;**63**(10):321–31. doi: 10.1111/j.1753-4887.2005.tb00110.x. [PubMed: 16295145].
19. Leung KM, Chung PK, Hagger MS. The effects of light volleyball intervention programme in improving selected physical and psychological attributes of older adults in Hong Kong. *Int J Sport Exerc Psychol*. 2018;**18**:1–12. doi: 10.1080/1612197x.2018.1462231.
20. Ahmadi S, Uchida MC, Gutierrez GL. Physical performance tests in male and female sitting volleyball players: Pilot study of Brazilian national team. *Asian J Sports Med*. 2019;**10**(2). e85984. doi: 10.5812/asjsm.85984.
21. Lee YA, Kim HC. Application of intensified program to increase physical fitness, mobility, and confidence on specific sports among volleyball sitting athletes. *Kor J Phys Multiple Health Disabil*. 2010;**53**(3):89–109. doi: 10.20971/kcpmd.2010.53.3.89.
22. Leung KM, Chung PK, Wong MY. *Promoting light volleyball among people with physical disabilities in Hong Kong*. Prague, Czech Republic: International Society of Behavioral Nutrition and Physical Activity; 2019.

23. Pahor M, Blair SN, Espeland M, Fielding R, Gill TM; Life Study Investigators, et al. Effects of a physical activity intervention on measures of physical performance: Results of the lifestyle interventions and independence for Elders Pilot (LIFE-P) study. *J Gerontol A Biol Sci Med Sci*. 2006;**61**(11):1157–65. doi: 10.1093/gerona/61.11.1157. [PubMed: 17167156].
24. U.S. Department of Health and Human Services Centres for Medicare and Medicaid Services. *Exercise programs for older adults: A systematic review and meta-analysis*. 2003.
25. Winnick JP, Short FX. The Brockport physical fitness test manual. *Human kinetics*. 2004.
26. TANITA. *Understanding your measurements*. 2018. Available from: https://www.tanita.com/en/understanding-your-measurements/.
27. Matsunaga N, Ito T, Noritake K, Sugiura H, Kamiya Y, Ito Y, et al. Correlation between the Gait Deviation Index and skeletal muscle mass in children with spastic cerebral palsy. *J Phys Ther Sci*. 2018;**30**(9):1176–9. doi: 10.1589/jpts.30.1176. [PubMed: 30214121]. [PubMed Central: PMC6127487].
28. Janssen I, Heymsfield SB, Ross R. Low relative skeletal muscle mass (sarcopenia) in older persons is associated with functional impairment and physical disability. *J Am Geriatr Soc*. 2002;**50**(5):889–96. doi: 10.1046/j.1532-5415.2002.50216.x. [PubMed: 12028177].
29. Portney LG, Watkins MP. *Foundations of clinical research: Applications to practice*. 4th ed. Upper Saddle River, NJ: Prentice Hall; 2014.
30. Government of Western Australia Child and Adolescent Health Service. *Body mass index assessment - child health*. 2017.
31. National Health Service. *What is the body mass index (BMI)*. 2016.
32. Zwinkels M, Verschuren O, Balemans A, Lankhorst K, Te Velde S, van Gaalen L, et al. Effects of a school-based sports program on physical fitness, physical activity, and cardiometabolic health in youth with physical disabilities: Data from the sport-2-stay-fit study. *Front Pediatr*. 2018;**6**:75. doi: 10.3389/fped.2018.00075. [PubMed: 29632853]. [PubMed Central: PMC5879083].
33. Yordy GA, Lent RW. Predicting aerobic exercise participation: Social cognitive, reasoned action, and planned behavior models. *J Sport Exerc Psychol*. 1993;**15**(4):363–74. doi: 10.1123/jsep.15.4.363.
34. Donnelly JE, Blair SN, Jakicic JM, Manore MM, Rankin JW, Smith BK, et al. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Med Sci Sports Exerc*. 2009;**41**(2):459–71. doi: 10.1249/MSS.0b013e3181949333. [PubMed: 19127177].
35. Swift DL, Johannsen NM, Lavie CJ, Earnest CP, Church TS. The role of exercise and physical activity in weight loss and maintenance. *Prog Cardiovasc Dis*. 2014;**56**(4):441–7. doi: 10.1016/j.pcad.2013.09.012. [PubMed: 24438736]. [PubMed Central: PMC3925973].
36. Willis LH, Slentz CA, Bateman LA, Shields AT, Piner LW, Bales CW, et al. Effects of aerobic and/or resistance training on body mass and fat mass in overweight or obese adults. *J Appl Physiol (1985)*. 2012;**113**(12):1831–7. doi: 10.1152/japplphysiol.01370.2011. [PubMed: 23019316]. [PubMed Central: PMC3544497].
37. King NA, Hopkins M, Caudwell P, Stubbs RJ, Blundell JE. Individual variability following 12 weeks of supervised exercise: identification and characterization of compensation for exercise-induced weight loss. *Int J Obes (Lond)*. 2008;**32**(1):177–84. doi: 10.1038/sj.ijo.0803712. [PubMed: 17848941].
38. Davis WJ, Wood DT, Andrews RG, Elkind LM, Davis WB. Concurrent training enhances athletes' strength, muscle endurance, and other measures. *J Strength Cond Res*. 2008;**22**(5):1487–502. doi: 10.1519/JSC.0b013e3181739f08. [PubMed: 18714239].
39. Celik A. Acute effects of cyclic versus static stretching on shoulder flexibility, strength, and spike speed in volleyball players. *Turk J Phys Med Rehabil*. 2017;**63**(2):124–32. doi: 10.5606/tftrd.2017.198. [PubMed: 31453440]. [PubMed Central: PMC6648128].
40. Ades PA, Savage P, Cress ME, Brochu M, Lee NM, Poehlman ET. Resistance training on physical performance in disabled older female cardiac patients. *Med Sci Sports Exerc*. 2003;**35**(8):1265–70. doi: 10.1249/01.MSS.0000079044.21828.0E. [PubMed: 12900677].
41. Bissonnette DR, Weir PL, Leigh L, Kenno K. The effects of a whole-body advanced vibration exercise program on flexibility, balance, and strength in seniors. *Phys Occup Ther Geriatr*. 2010;**28**(3):225–34. doi: 10.3109/02703181.2010.503913.
42. Grabara M, Szopa J. Effects of hatha yoga exercises on spine flexibility in women over 50 years old. *J Phys Ther Sci*. 2015;**27**(2):361–5. doi: 10.1589/jpts.27.361. [PubMed: 25729168]. [PubMed Central: PMC4339138].