

Endurance Outcomes and Between-Group Effect Sizes of a Differentiated Special-Exercise Methodology for University Students with Disabilities during Sitting Volleyball Training

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ABSTRACT:

This companion study examined endurance outcomes and the between-group statistical robustness of a differentiated special-exercise methodology for sitting-volleyball training in university students with musculoskeletal-system injuries and lower-limb amputation. A three-stage pedagogical experiment (2020–2023) was conducted with 24 students, allocated to a control group (CG, $n = 12$) and an experimental group (EG, $n = 12$). The EG followed a purpose-built complex of special, approach, and technical exercises within anaerobic-oriented weekly microcycles differentiated by functional nosology. Six endurance tests were assessed before and after the intervention using paired-samples t -tests; between-group post-intervention differences were additionally evaluated with Welch's independent-samples t -test, and effect sizes were computed as Cohen's d with 95% confidence intervals. The EG improved significantly on all six endurance tests ($t = 3.51$ – 4.43 , $p < .01$ to $p < .001$, $d = 1.43$ – 1.81 , all large), exceeding the CG ($d = 0.72$ – 0.86). Between-group comparison favoured the EG on all 16 outcome indicators assessed across the wider research program ($d = 0.47$ – 1.08), reaching significance for 3 of 16 despite limited statistical power at $n = 12$ per group. The differentiated methodology produced large, statistically robust endurance gains, and the effect-size analysis supports its practical value even where between-group significance was not reached.

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Keywords: sitting volleyball, para-volleyball, adaptive sport, disability, endurance, effect size, Cohen's d, differentiated training.

Introduction

Adaptive sport participation is associated with improved physical, functional, and psychosocial outcomes for people with disabilities (Heasley et al., 2026), yet training methodologies for sitting volleyball that are differentiated by disability nosology remain underdeveloped, particularly regarding cardiorespiratory endurance and rigorous between-group statistical evaluation. A companion study reported large within-group gains in anthropometric, functional, and speed-strength outcomes from a differentiated special-exercise methodology for university students with musculoskeletal-system injuries and lower-limb amputation; the present paper extends that work by reporting endurance outcomes and a between-group, effect-size-based statistical analysis across the full outcome set.

Small-sample adaptive-sport intervention studies frequently rely on within-group significance testing alone, which can overstate confidence in a methodology's effect when between-subject variance and limited power are not also considered (Abt et al., 2020). Wheelchair-sport research increasingly reports effect sizes and confidence intervals alongside p-values to address this (Buceta-Toro et al., 2025), and functional classification frameworks such as that used in wheelchair basketball illustrate the value of nosology-sensitive reporting more broadly.

The present study therefore aimed to (a) evaluate the effect of the differentiated methodology on endurance qualities, and (b) rigorously quantify, via between-group inferential statistics and effect sizes with confidence intervals, the strength of evidence for the methodology's benefit across the full set of physical and functional outcomes assessed in the wider research program.

Sitting volleyball has long served as a tool for teaching tolerance and disability awareness (Belousov, 2016), and the Paralympic Games and associated awareness programs are understood to promote peaceful coexistence and more equitable perceptions of disability (Brittain, 2012), building

disability awareness among school and university populations (Fitzgerald, 2012; Tindall, 2013). Related adapted-volleyball formats have also been evaluated directly for their physical and psychological benefits: sitting light volleyball interventions have produced significant gains in cardiovascular endurance and body composition among adults with physical disabilities relative to a control group (Leung et al., 2021), improved physical fitness among students with physical disabilities in a pilot quasi-experimental design (Wong & Leung, 2020), and were positively evaluated by participants using a social-ecological qualitative framework (Leung et al., 2020).

Descriptive and comparative studies of national and elite sitting-volleyball squads report distinct physical-fitness profiles that inform classification and training (Ahmadi et al., 2020; Cavedon et al., 2022), while sport-mastery differences between athletes with and without disabilities in sitting volleyball have also been documented (D'Isanto, 2020). This parallels a broader body of work on wheelchair-sport classification and body composition (Cavedon et al., 2018, 2020, 2021; Stojanović et al., 2022; Villaceros et al., 2020) and on adapted physical education for individuals with disabilities more generally (Jariono et al., 2025). The present study extends this literature to endurance outcomes and between-group statistical rigor in sitting volleyball.

2. Methodology

Design: A three-stage pedagogical (quasi-experimental) study was conducted between 2020 and 2023 at the Scientific Research Institute of Physical Education and Sport (Chirchiq, Uzbekistan), extending an earlier applied study of special-exercise training in sitting volleyball for students with disabilities and building on the companion analysis of anthropometric, functional, and speed-strength outcomes from the same cohort. Stage 1 (diagnostic) reviewed training-load literature and the national squad's experience; Stage 2 designed the special/approach/technical exercise complex

and conducted the main experiment; Stage 3 evaluated outcomes statistically.

Participants/Sample: Twenty-four university students with disabilities (musculoskeletal-system injuries and lower-limb amputation) were allocated to a control group (CG, $n = 12$) and an experimental group (EG, $n = 12$); baseline comparability is reported in the companion paper.

Instruments: Six standardised endurance tests were recorded before and after the intervention in both groups. Heart rate was monitored throughout training to individualise intensity.

Procedure: The EG followed the differentiated methodology described in the companion paper: special, approach, and technical exercises applied in a fixed sequence within weekly microcycles incorporating an anaerobic training regimen, with exercise combinations and dosage differentiated by nosology (musculoskeletal-system injury versus lower-limb amputation). The CG continued the standard, non-differentiated program.

Data Analysis: Within-group pre-to-post change was evaluated using a two-tailed paired-

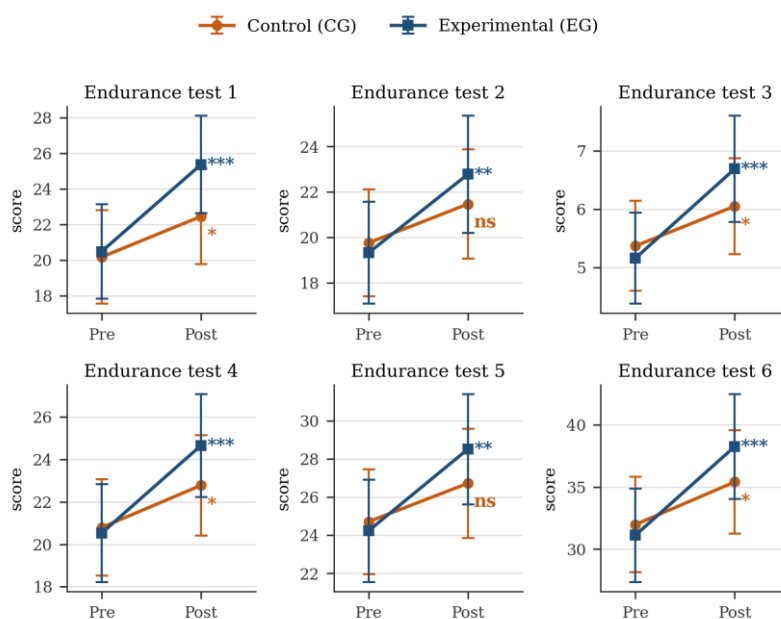
samples t-test ($df = 11$ per group). To extend this analysis, between-group differences in post-intervention scores across all 16 outcome indicators assessed in the wider research program (4 anthropometric/functional, 6 speed-strength, 6 endurance) were evaluated using Welch's independent-samples t-test, which does not assume equal variances; the Welch-Satterthwaite equation estimated degrees of freedom. Effect sizes were computed as Cohen's d with 95% confidence intervals (Hedges & Olkin approximation), and classified as trivial (< 0.2), small ($0.2-0.49$), medium ($0.5-0.79$), or large (≥ 0.8) (Abt et al., 2020). Significance was set at $\alpha = .05$ for all tests.

3. Results

Endurance Qualities. The EG improved significantly on all six endurance tests ($t = 3.51-4.43$, $p < .01$ to $p < .001$, $d = 1.43-1.81$, all large). The CG improved significantly on four of six tests ($t = 2.09-2.11$, $p < .05$, $d = 0.85-0.86$, large); two tests did not reach significance ($d = 0.72$, medium) (Table 1, Figure 1). The mean relative increase was 22.0% (EG) versus 10.2% (CG).

Table 1 Change in endurance test scores in the control (CG) and experimental (EG) groups (mean $\pm$ SD; $n = 12$ per group).

Test	Group	Pre	Post	t (df=11)	p	d
1	CG	20.17 $\pm$ 2.62	22.45 $\pm$ 2.67	2.11	< .05	0.86
	EG	20.48 $\pm$ 2.66	25.36 $\pm$ 2.74	4.43	< .001	1.81
2	CG	19.76 $\pm$ 2.36	21.47 $\pm$ 2.41	1.76	> .05	0.72
	EG	19.32 $\pm$ 2.24	22.78 $\pm$ 2.58	3.51	< .01	1.43
3	CG	5.37 $\pm$ 0.77	6.05 $\pm$ 0.82	2.09	< .05	0.85
	EG	5.16 $\pm$ 0.78	6.69 $\pm$ 0.91	4.42	< .001	1.81
4	CG	20.79 $\pm$ 2.28	22.78 $\pm$ 2.37	2.10	< .05	0.86
	EG	20.53 $\pm$ 2.31	24.66 $\pm$ 2.43	4.27	< .001	1.74
5	CG	24.71 $\pm$ 2.74	26.72 $\pm$ 2.86	1.76	> .05	0.72
	EG	24.23 $\pm$ 2.68	28.51 $\pm$ 2.89	3.76	< .01	1.54
6	CG	31.98 $\pm$ 3.83	35.41 $\pm$ 4.14	2.11	< .05	0.86
	EG	31.12 $\pm$ 3.76	38.26 $\pm$ 4.23	4.37	< .001	1.78

Figure 1 *Endurance Test Scores Before and After the Intervention*

Note. Values are mean $\pm$ SD. CG = control group; EG = experimental group. * $p < .05$, ** $p < .01$, *** $p < .001$; ns = not significant.

Between-Group Effect-Size Analysis. Post-intervention scores were compared directly between the EG and CG across all 16 outcome indicators assessed in the wider research program using Welch's *t*-test (Table 2, Figure 2). The EG scored higher than the CG on every indicator, with effect sizes ranging from small-to-medium ($d = 0.47$) to large ($d = 1.08$). Three comparisons

reached conventional statistical significance ($p < .05$): endurance test 1 ($t = 2.63$, $p = .015$, $d = 1.08$), speed-strength test 6 ($t = 2.25$, $p = .036$, $d = 0.92$), and speed-strength test 2 ($t = 2.32$, $p = .030$, $d = 0.95$). The remaining 13 comparisons showed effect sizes in the medium-to-large range without reaching significance at this sample size, most plausibly reflecting limited statistical power (the study was adequately powered to detect only large between-group effects, approximately $d \geq 0.9$, at $n = 12$ per group) rather than absence of a true effect.

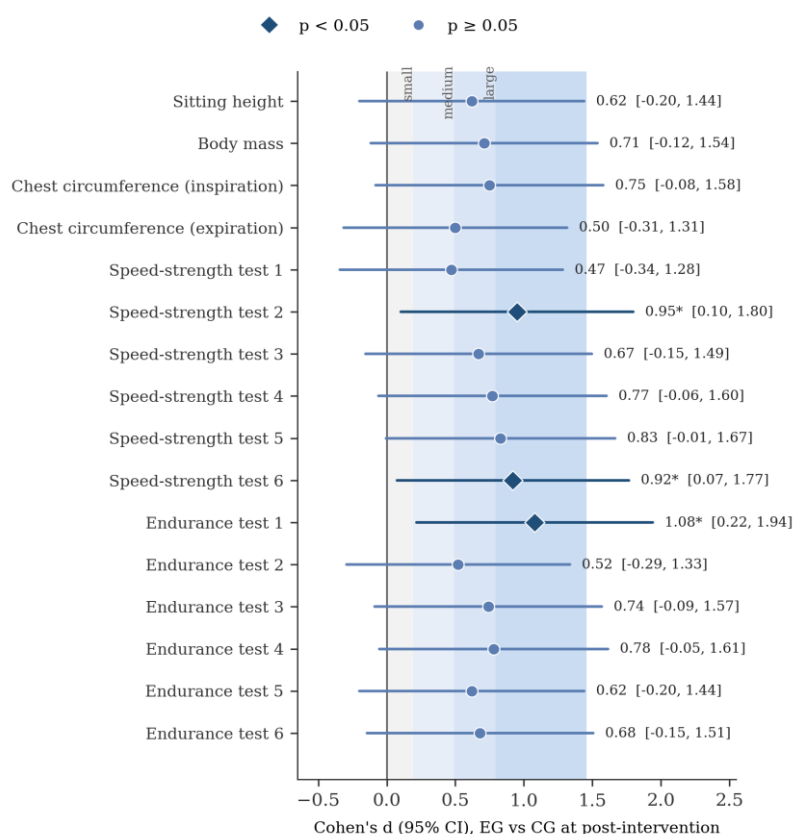
Table 2 *Between-group (Welch independent-samples *t*-test) comparison of post-intervention scores, EG vs CG, across all 16 outcome indicators ($n = 12$ per group).*

Indicator	t	df	p	d
Sitting height	1.52	22.0	.144	0.62
Body mass	1.73	22.0	.098	0.71
Chest circumference, inspiration	1.83	22.0	.081	0.75
Chest circumference, expiration	1.22	22.0	.234	0.50
Speed-strength test 1	1.15	22.0	.262	0.47
Speed-strength test 2	2.32	21.9	.030*	0.95
Speed-strength test 3	1.64	21.7	.115	0.67
Speed-strength test 4	1.89	21.0	.073	0.77
Speed-strength test 5	2.02	21.9	.055	0.83
Speed-strength test 6	2.25	21.1	.036*	0.92
Endurance test 1	2.63	22.0	.015*	1.08
Endurance test 2	1.29	21.9	.212	0.52

Indicator	t	df	p	d
Endurance test 3	1.81	21.8	.084	0.74
Endurance test 4	1.92	22.0	.068	0.78
Endurance test 5	1.53	22.0	.141	0.62
Endurance test 6	1.67	22.0	.109	0.68

* $p < .05$. d = Cohen's d (between-group); classified per conventional thresholds (Abt et al., 2020). Full 95% confidence intervals are illustrated in Figure 2.

Figure 2 Forest Plot of Between-Group Effect Sizes (Cohen's d) With 95% Confidence Intervals



Note. EG = experimental group; CG = control group. Shaded bands denote conventional small (0.2), medium (0.5), and large (0.8) effect-size thresholds (Abt et al., 2020). Diamonds mark comparisons significant at $p < .05$.

4. Discussion

The endurance results extend the companion paper's findings by showing that the differentiated methodology also produces large, consistent gains in cardiorespiratory/muscular endurance, not only in speed-strength and anthropometric/functional indices. Combined with the speed-strength findings, this suggests the methodology's benefit is not confined to a single physical-fitness domain. The magnitude of the

endurance and speed-strength gains observed across the wider research program is consistent with evidence that structured, sport-specific exercise progressions acutely enhance neuromuscular readiness relative to non-specific preparation (Behm & Chaouachi, 2011; Kruse et al., 2015), and with findings that sustained wheelchair-based training improves cardiorespiratory endurance capacity and physical work performance in populations with mobility impairment (Bougenot et al., 2003).

The between-group effect-size analysis is, however, the more methodologically important contribution of this paper. Within-group paired comparisons benefit from each participant serving as their own control, which increases

power even at $n = 12$; between-group comparisons must overcome both between-subject variance and a smaller effective sample, so the study was powered to detect only large between-group effects with reasonable probability. The observed effect sizes (median $d \approx 0.73$) therefore fall within a range where a true, practically meaningful effect can readily coexist with a non-significant p-value — a pattern that should be read as inconclusive-but-promising rather than as evidence of no effect, and that argues for effect-size-based rather than significance-only reporting in small-sample adaptive-sport intervention research (Abt et al., 2020).

This study shares the limitations of the companion paper: a modest, single-institution sample; non-randomised group allocation, albeit with demonstrated baseline equivalence; and the absence of a formal a priori power calculation, functional classification stratification, and psychosocial outcome measures. Psychosocial outcomes were also not measured despite their documented relevance to athletes with disabilities (Aboulhosn et al., 2026), and outcomes were not stratified by a formal functional classification scale of the kind used in other wheelchair sports (Cavedon et al., 2020), and body-composition or bone-health outcomes, which have been shown to be sensitive to training exposure in athletes with physical impairment (Cavedon et al., 2021), were not assessed. A structured injury-surveillance protocol was also not implemented;

this is a relevant gap given that repetitive overhead and trunk-loading actions in volleyball have been linked to rectus abdominis strain (Bulmash et al., 2024) and that jumping-sport literature more broadly implicates persistent tissue-level loading, rather than altered central pain processing, in overuse conditions such as patellar tendinopathy (Vallance et al., 2025).

5. Conclusion

The differentiated special-exercise methodology produced large within-group endurance gains and medium-to-large between-group effect sizes across all 16 outcome indicators assessed in this research program, with statistical significance reached for a minority of comparisons — most plausibly reflecting limited power rather than absence of effect. Together with the companion paper, these findings support the practical value of nosology-differentiated training and justify a larger, adequately powered, multi-site confirmatory trial.

- Endurance-focused microcycles should be maintained alongside speed-strength work within the differentiated methodology, as both domains showed comparable benefit.
- Future adaptive-sport intervention studies should report effect sizes with confidence intervals alongside p-values, particularly at small sample sizes.
- A multi-site trial with a priori power calculation and functional-classification stratification is recommended to confirm the between-group effects observed here.

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