© APR 2025 | IRE Journals | Volume 8 Issue 10 | ISSN: 2456-8880
DOI: https://doi.org/10.64388/ire1724737

Impact of Complex Training and High-Intensity Interval Training on Balance among Bachelor Degree Students

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Abstract- ***Background: Balance, the ability to keep the centre of mass over the base of support, underlies safe landing, quick changes of direction and injury prevention in field and court sports. Complex training (CT), which couples heavy resistance exercises with biomechanically similar plyometric work, and high-intensity interval training (HIIT), which alternates short maximal efforts with recovery, are popular methods of physical preparation, but their influence on balance in young adults has received little direct comparison. Objective: To compare the effects of a 12-week complex training programme and a 12-week HIIT programme on balance, measured by the stork balance test, among male handball-playing bachelor degree students. Methods: Ninety male students (18–21 years) from bachelor's degree colleges in Hyderabad were randomly assigned to a Complex Training Group (CTG, n = 30), a High-Intensity Interval Training Group (HIITG, n = 30) or a Control Group (CG, n = 30). The experimental groups trained three sessions per week for twelve weeks at progressively increasing intensity (75%, 80% and 85%); the control group continued its normal routine. Balance time (seconds) was recorded before and after the intervention. Paired t-tests examined within-group change, one-way ANOVA examined baseline equivalence and between-group differences in change scores, and Bonferroni-adjusted Welch t-tests were used for pairwise comparisons (α = 0.05). Results: The groups were equivalent at baseline (F = 0.098, p = 0.907). Balance time increased by 6.653 s (26.01%) in CTG, 5.810 s (22.95%) in HIITG and 0.647 s (2.57%) in CG. The groups differed significantly in change (F(2, 87) = 35553.41, p < 0.001, η² = 0.999). Both training groups improved more than the control group, and CTG improved more than HIITG (mean difference 0.843 s, p < 0.001). Conclusion: Both complex training and HIIT improved stork-balance performance of undergraduate handball players, and complex training produced the greater gain. Including single-leg and landing-oriented plyometric work within strength-based complexes appears to be a practical way to develop balance alongside power.***

Index Terms- ***balance, complex training, handball, high-intensity interval training, postural control, stork balance test, undergraduate students***

I. INTRODUCTION

Balance ability is a component of motor performance that contributes to athletic skill and to the control of joint stability during sport. A review of the literature concluded that better balance is associated with better performance in several sports and that balance training is linked to a lower risk of injury, particularly at the ankle (Hrysomallis, 2007, 2011). Postural control also adapts to the type of sport and motor experience a person has accumulated (Paillard, 2017).

In handball, players repeatedly jump, land on one or both feet, absorb contact and change direction at speed (Karcher & Buchheit, 2014; Wagner, Finkenzeller, Würth & von Duvillard, 2014). Each of these actions demands rapid correction of body position, so training that improves neuromuscular control is of obvious value. Balance training itself is known to produce adaptations at spinal and supraspinal levels (Taube, Gruber & Gollhofer, 2008), and systematic reviews indicate that balance training improves balance performance in youth and adults (Zech et al., 2010; Gebel, Lesinski, Behm & Granacher, 2018).

Complex training pairs a heavy strength exercise with a plyometric exercise of similar movement pattern, such as a squat followed by a jump. The heavy contraction is thought to leave the neuromuscular system temporarily more ready for explosive work (Sale, 2002), and plyometric components are known to improve jumping and related abilities (Markovic, 2007; Freitas, Martinez-Rodriguez, Calleja-González & Alcaraz, 2017). Because single-leg hops, bounds and landings force the athlete to stabilise the body under load, such exercises may also challenge the postural control system. Combining plyometric with balance-oriented work has, for example, improved sprint and shuttle-run results in children more than plyometrics alone (Chaouachi, Othman, Hammami, Drinkwater & Behm, 2014).

High-intensity interval training consists of repeated bouts of near-maximal effort separated by recovery, and it places substantial neuromuscular demands on the body in addition to the metabolic load (Buchheit & Laursen, 2013). Exercises such as sprint intervals, cone runs, lateral bounds and reactive drills involve rapid acceleration, deceleration and balance corrections, which may transfer to postural stability.

Despite the widespread use of both methods, studies that compare them directly with respect to balance in undergraduate athletes are limited. The present investigation was designed to fill part of that gap.

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II. OBJECTIVES

1) To assess the effect of a 12-week complex training programme on the balance of bachelor degree students who play handball.
2) To assess the effect of a 12-week high-intensity interval training programme on the same variable.
3) To compare the two programmes with each other and with a control group.

III. HYPOTHESES

1) Complex training will significantly improve balance.
2) High-intensity interval training will significantly improve balance.
3) Both experimental groups will improve significantly more than the control group.
4) The complex training group and the HIIT group will differ significantly in the improvement of balance.

IV. METHODOLOGY

A. Participants

Ninety male handball players were identified from various bachelor's degree colleges in Hyderabad. The prospective participants were informed about the purpose of the study, the testing procedures, the training requirements and their expected involvement. Those who volunteered and met the requirements of the investigation were included. Their ages ranged from 18 to 21 years. They were told that participation was voluntary and that they could withdraw at any stage if they experienced discomfort or were unwilling to continue. All ninety participants completed the study, and no dropouts occurred.

B. Design and grouping

A randomised three-group pre-test/post-test design was adopted. Participants were randomly assigned to three equal groups of thirty:

- **Group I – Complex Training Group (CTG):** followed the prescribed complex training programme.
- **Group II – High-Intensity Interval Training Group (HIITG):** followed the prescribed HIIT programme.
- **Group III – Control Group (CG):** continued its regular routine without either experimental programme.

The experimental programmes lasted twelve weeks with three sessions per week.

C. Criterion variable and test

Table 1. Criterion variable, test and unit of measurement

Criterion variable	Test	Unit
Balance	Stork balance test	Seconds

The stork balance test (Johnson & Nelson, 1979) assesses static balance on one leg. Time in seconds was recorded, and a longer time represents better balance. The test was administered before the first training session and after the twelfth week.

D. Training programmes

Table 2. Twelve-week complex training schedule (Group I)

Weeks	Strength exercises	Plyometric and handball-specific exercises	Sets × repetitions	Intensity
I–IV	Back squat, front squat, deadlift, shoulder press, pull-ups	Depth jumps, tuck jumps, bounding, broad jumps	2 × 5	75%
V–VIII	Heavy squat, leg press, bench press, core stability exercises	Depth jump to sprint, single-leg hops, lateral cone jumps, medicine-ball throws	3 × 6	80%
IX–XII	Fast-break drill, defensive shuffle, sprint-and-shoot drill, jump-shot drill	Fast-attack drill, match simulation, defensive recovery drill	3 × 7	85%

Table 3. Twelve-week high-intensity interval training schedule (Group II)

Weeks	Exercises	Sets × repetitions	Intensity
I–IV	Dynamic warm-up, high-knees running, butt kicks, jumping jacks, shuttle runs (10–20 m), body-weight squats, jump squat to sprint, kettlebell clean and press, battle-rope waves, plyometric push-ups	2 × 5	75%
V–VIII	Dynamic stretching, 15 m sprint intervals, zig-zag cone runs, mountain climbers, burpees, medicine-ball chest pass, mobility drills, repeated-sprint-ability drill, broad jumps	3 × 6	80%

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Weeks	Exercises	Sets × repetitions	Intensity
IX–XII	Dynamic mobility, sprint-and-backpedal drill, depth jumps, kettlebell swings, battle-rope intervals, clap push-ups, lateral bounds, bicycle crunches, reactive cone drills, plyometric box jumps, medicine-ball power throws	3 × 7	85%

Both programmes therefore progressed in volume and intensity every four weeks. The control group did not take part in either programme.

E. Statistical analysis

Means and standard deviations were calculated for each group. Pre- to post-test change within groups was tested with the paired t-test. Equivalence at baseline and group differences at post-test were examined with one-way ANOVA. Because the groups were equivalent at baseline, the principal analysis compared the change scores (post minus pre) with one-way ANOVA; variances of the change scores were homogeneous (Levene's test, $p = 0.533$) and Welch's ANOVA gave the same result. Pairwise comparisons used Welch t-tests with Bonferroni correction. An analysis of covariance gave the same conclusions, but because the regression slopes differed slightly among groups it was treated as supportive only. Effect size was expressed as η^2. The level of significance was 0.05. Analyses were carried out in Python (SciPy and statsmodels).

V. RESULTS

Table 4. Baseline equivalence of the groups (one-way ANOVA on pre-test balance time)

Group	n	Pre-test (Mean ± SD, s)	F (df = 2, 87)	p
CTG	30	25.580 ± 3.633	0.098	0.907
HIITG	30	25.313 ± 3.396		
CG	30	25.193 ± 3.380		

The groups did not differ significantly before the intervention.

Table 5. Pre-test and post-test balance time and paired t-test results

Group	Pre-test (Mean ± SD, s)	Post-test (Mean ± SD, s)	Mean change (s)	Change (%)	t (df = 29)	p
CTG	25.580 ± 3.633	32.233 ± 3.677	6.653	26.01	297.66	< 0.001
HIITG	25.313 ± 3.396	31.123 ± 3.379	5.810	22.95	331.65	< 0.001
CG	25.193 ± 3.380	25.840 ± 3.416	0.647	2.57	69.80	< 0.001

All groups improved significantly, but the gain in the control group was small compared with those in the experimental groups. Post-test balance time also differed among groups ($F(2, 87) = 28.69$, $p < 0.001$).

Table 6. Comparison of change scores among groups (one-way ANOVA)

Group	Mean change ± SD (s)	F (df = 2, 87)	p	η^2
CTG	6.653 ± 0.122	35553.41	< 0.001	0.999
HIITG	5.810 ± 0.096			
CG	0.647 ± 0.051			

Table 7. Pairwise comparisons of change scores (Welch t-test, Bonferroni-adjusted)

Comparison	Mean difference (s)	t	Adjusted p
CTG vs CG	6.007	248.25	< 0.001
HIITG vs CG	5.163	260.55	< 0.001
CTG vs HIITG	0.843	29.70	< 0.001

Both experimental programmes were superior to the control condition, and complex training was superior to HIIT.

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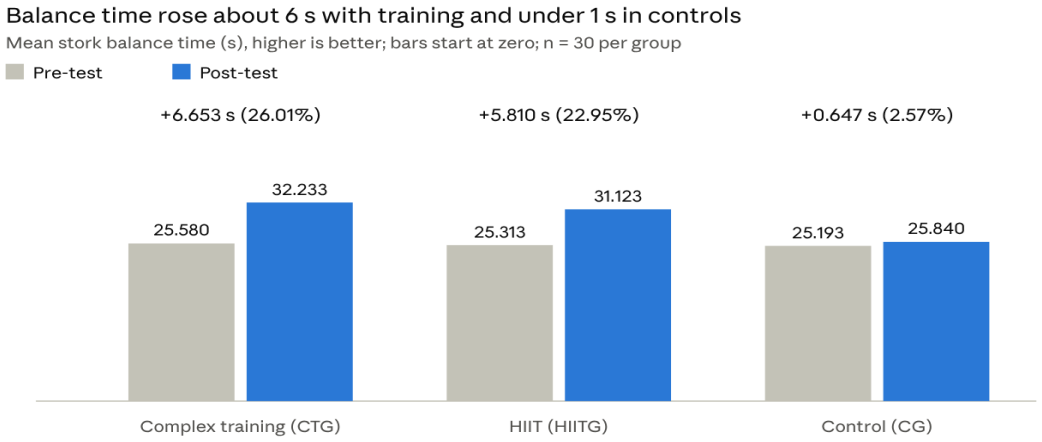


Figure 1. *Pre-test and post-test mean stork balance time (s) of the three groups.*

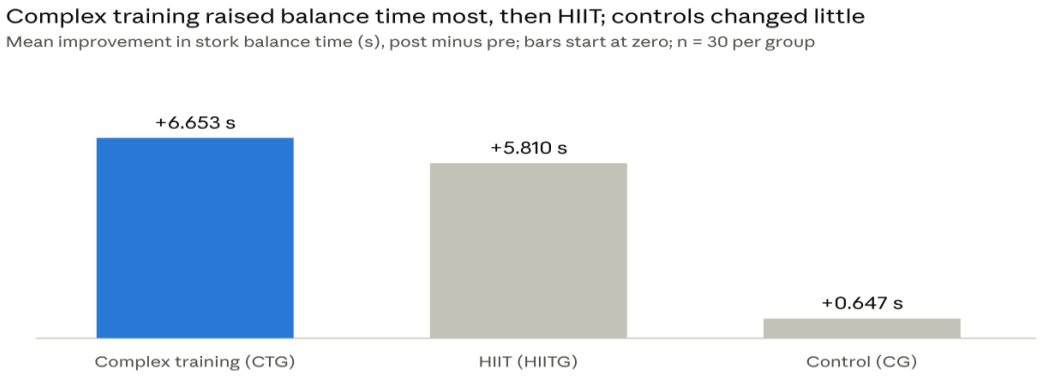


Figure 2. *Mean improvement in stork balance time (s) of the three groups.*

VI. DISCUSSION

The purpose of the study was to examine whether complex training and HIIT improve balance in undergraduate handball players and which of the two is more effective. Since the three groups started with practically identical values, the differences at the end of twelve weeks are attributable mainly to the training received. The research hypotheses H1 to H4 are therefore supported.

The gains in both experimental groups agree with the view that dynamic, ground-based training stresses the neuromuscular systems that govern posture. Exercises such as single-leg hops, lateral cone jumps, depth jumps and bounds require the athlete to absorb force and then stabilise the body, which resembles the demands of balance training (Taube et al., 2008; Zech et al., 2010). Heavy squats, leg presses and core stability work may add to this effect by improving the strength of the trunk and lower limbs, on which postural stability depends (Granacher, Gollhofer, Hortobágyi, Kressig & Muehlbauer, 2013).

The complex training group improved more than the HIIT group. A possible reason is that the complex programme joined heavy loading to landing- and single-leg-based plyometrics and, in the final phase, handball-specific drills in which players decelerate, jump and land, giving a more direct and repeated challenge to joint control. The finding is consistent with reports that combining plyometric and balance-type work yields larger benefits than plyometric work alone (Chaouachi et al., 2014) and with evidence that complex training is effective in team sports (Freitas et al., 2017).

The HIIT group also improved markedly. Sprint intervals, cone runs, backpedalling, lateral bounds and reactive drills involve repeated accelerations, stops and direction changes that depend on continuous postural adjustment (Buchheit & Laursen, 2013). HIIT is simple to organise, and these results suggest it is a useful option when equipment is limited.

The small improvement of the control group is likely to reflect familiarity with the test and habitual activity.

Limitations. The study included only male students from colleges in one city, measured only one static balance test, and had no follow-up to examine retention. The change scores were very uniform within each group, which produced extremely large test statistics and effect sizes; replication with other samples and with dynamic balance tests is advisable before the magnitude of the gains is generalised.

VII. CONCLUSION

Within the limits of this study, twelve weeks of complex training and of high-intensity interval training significantly improved the balance of male undergraduate handball players compared with a control group, and complex training produced the larger improvement. The null hypothesis is rejected at the 0.05 level.

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