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Effects of Complex Training and High-Intensity Interval Training on Speed and Agility among Male College-Level Handball Players

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Abstract- ***Background: Handball is an intermittent invasive sport in which repeated sprints, sudden changes of direction and explosive take-offs decide many match situations. Complex training (CT), which pairs a heavy resistance exercise with a biomechanically similar plyometric exercise, and high-intensity interval training (HIIT), which alternates brief maximal-effort bouts with recovery, are both widely used to develop these qualities. Direct comparisons of the two methods in college handball players are scarce. Objective: To examine and compare the effects of a 12-week complex training programme and a 12-week HIIT programme on sprint speed and agility in male college-level handball players. Methods: Ninety male handball players (18–21 years) from undergraduate colleges in Hyderabad were randomly allocated 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 two experimental groups trained three days a week for twelve weeks; the control group continued its usual routine. Speed was measured with a 50 m sprint and agility with a 4 × 10 m shuttle run (both in seconds) before and after the intervention. Pre-to-post changes were examined with paired t-tests, baseline equivalence with one-way ANOVA, and between-group differences in change scores with one-way ANOVA (Welch-corrected because variances were unequal) followed by Bonferroni-adjusted pairwise comparisons. Significance was set at $p < 0.05$. Results: Baseline values did not differ among groups (speed $p = 0.996$; agility $p = 0.995$). Sprint time fell by 0.273 s in CTG (3.67%), 0.228 s in HIITG (3.06%) and 0.024 s in CG (0.32%). Shuttle-run time fell by 0.425 s in CTG (4.18%), 0.350 s in HIITG (3.44%) and 0.038 s in CG (0.37%). Group differences in change scores were significant for both variables (speed $F = 493.65$; agility $F = 214.09$; both $p < 0.001$). Both experimental groups improved significantly more than the control group, and CTG improved significantly more than HIITG in speed ($p < 0.001$) and agility ($p = 0.010$). Conclusion: Twelve weeks of either complex training or HIIT improved speed and agility in male college handball players, with complex training producing the larger gains. Coaches seeking to develop sprinting and change-of-direction ability may therefore prioritise complex training and use HIIT as an effective complementary method.***

Index Terms- ***agility, college athletes, complex training, handball, high-intensity interval training, sprint speed***

I. INTRODUCTION

Handball places heavy physical demands on its players. Match analyses show that play consists of many short sprints, rapid accelerations and decelerations, contacts with opponents, jumps and throws, separated by brief periods of lower-intensity movement (Michalsik, Aagaard & Madsen, 2013; Karcher & Buchheit, 2014). Because decisive actions such as a fast break, a defensive recovery or a gap-closing step depend on how quickly a player can accelerate and redirect the body, sprint speed and agility are regarded as key components of handball performance (Wagner, Finkenzeller, Würth & von Duvillard, 2014).

Agility is generally understood as a rapid whole-body movement with a change of velocity or direction in response to a stimulus (Sheppard & Young, 2006). Muscle power of the lower limbs is closely related to the ability to accelerate and to change direction quickly (Young, James & Montgomery, 2002), which explains why training that develops force and rate of force development is popular among team-sport coaches.

Complex training alternates a heavy-load strength exercise with a plyometric or ballistic exercise that resembles it in movement pattern. The rationale is that the heavy contraction may temporarily enhance neuromuscular readiness for the explosive exercise that follows, an effect usually attributed to post-activation potentiation (Sale, 2002; Tillin & Bishop, 2009). Reviews of team-sport studies indicate that complex training can improve jumping, sprinting and change-of-direction performance (Freitas, Martinez-Rodriguez, Calleja-González & Alcaraz, 2017; Cormier, Freitas, Rubio-Arias & Alcaraz, 2020).

High-intensity interval training consists of repeated short bouts of near-maximal work interspersed with recovery. It is time-efficient and produces both metabolic and neuromuscular adaptations (Gibala, Little, Macdonald & Hawley, 2012; Buchheit & Laursen, 2013a, 2013b). When intervals are run as sprints or shuttles, they also load the muscles in a

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manner specific to the movement demands of court sports.

Although both methods are used in practice, few investigations have compared them directly on speed and agility in college-level handball players. Clarifying which approach yields larger improvements would help coaches design efficient pre-season and in-season programmes. The present study was therefore undertaken to compare the effects of complex training and HIIT on these two performance variables.

II. OBJECTIVES

1) To determine the effect of a 12-week complex training programme on speed and agility of male college-level handball players.
2) To determine the effect of a 12-week high-intensity interval training programme on speed and agility of male college-level handball players.
3) To compare the effects of complex training and high-intensity interval training with each other and with a control group on speed and agility.

III. HYPOTHESES

Research hypotheses

1) Complex training will produce a significant improvement in speed and agility of male college handball players.
2) High-intensity interval training will produce a significant improvement in speed and agility of male college handball players.
3) Both experimental groups will show significantly greater improvement in speed and agility than the control group.
4) The two experimental groups will differ significantly from each other in the improvement of speed and agility.

IV. METHODOLOGY

A. Participants

Ninety male handball players aged 18 to 21 years were identified from various bachelor's degree colleges in Hyderabad. Prospective participants were informed about the purpose of the study, the testing procedures, the training requirements and the commitment expected of them. Those who volunteered and met the requirements of the investigation were included. Participants were told that participation was voluntary and that they could withdraw at any stage if they felt discomfort or were unwilling to continue. All ninety participants completed the study and there were no dropouts.

B. Experimental design and grouping

A randomised three-group pre-test/post-test design was used. The 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 the regular routine without either experimental programme.

The experimental programmes lasted twelve weeks with three sessions per week (Monday, Wednesday and Friday).

C. Criterion variables and tests

Table 1. Criterion variables, tests and units of measurement

S.No	Criterion variable	Test	Unit
1	Speed	50 m sprint	Seconds
2	Agility	4 × 10 m shuttle run	Seconds

Both tests were administered before the first training session (pre-test) and after the twelfth week, following a reduced-load week to allow recovery (post-test). Lower times indicate better performance.

D. Training programmes

Every session lasted about 55–70 minutes and followed the same structure: a 10–12 minute warm-up (easy jogging, dynamic mobility, movement drills and three progressive build-ups), the main training block, and a 5–8 minute cool-down of easy walking or jogging with breathing and static stretching. Load was increased progressively and reduced in weeks 4 and 8 (about 15–20% lower volume) and in the final two weeks to promote recovery before testing.

Table 2. Summary of the 12-week training programme (per session, by phase)

Weeks	Phase	Complex Training Group (CTG)	HIIT Group (HIITG)	Intensity
1–2	Familiarisation	Bodyweight or goblet squat with squat or broad jump (2 × 8 + 2 × 4–5); push-up with medicine-ball chest pass; split squat with split-squat jump; 6 × 10–15 m accelerations	6–7 × 15 s fast run / 45 s walk; 4 × 10 m shuttle; modified sit-ups 2 × 10–12; stork balance 3 × 15–20 s per leg	Moderate

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Weeks	Phase	Complex Training Group (CTG)	HIIT Group (HIITG)	Intensity
3	Foundation	Squat 3 × 6 + squat jump 3 × 4; light hip hinge 2 × 8 + broad jump 2 × 4; 6 × 20 m accelerations	8 × 15 s fast run / 45 s walk; 5 × 10 m shuttle; sit-ups 3 × 10; stork balance 3 × 20 s	Moderate
4	Deload	Squat 2 × 6 + squat jump 2 × 4; split squat with lateral bound; 4 × 20 m accelerations	6 × 15 s fast / 45 s walk; 4 × 10 m shuttle; sit-ups 2 × 10	Low–moderate
5–7	Development	Squat 3 × 5–6 + squat jump 3 × 4; split squat or hip hinge with lateral bound or broad jump; 6–8 × 20–25 m accelerations	8–10 × 20 s hard run / 60 s walk; 5–6 × 10 m shuttle; sit-ups 3 × 12–15; stork balance 3 × 25–30 s	Moderate–high to high
8	Deload	Squat 2 × 5 + squat jump 2 × 4; hip hinge 2 × 6 + broad jump 2 × 4; 6 × 20 m accelerations	7 × 20 s hard run / 60 s walk; 4 × 10 m shuttle; sit-ups 2 × 12	Moderate
9–10	Specific preparation	Squat 3 × 4–5 with broad, vertical or squat jumps 3 × 4; split squat with lateral bound; 6–8 × 20 m handball accelerations	8–9 × 20 s hard shuttle or run / 60 s recovery; 5–6 × 10 m change-of-direction runs; sit-ups 3 × 15; stork balance 3 × 30 s	High
11	Peak / taper	Squat 2 × 4–5 + squat jump 2 × 4; split squat 2 × 5 with lateral bound; 6 × 20 m accelerations	6 × 20 s hard shuttle or run / 60 s recovery; 4 × 10 m change-of-direction runs	Moderate–high
12	Taper and post-test	Light technique session: squat 2 × 5 + jump 2 × 3; 4 × 15 m relaxed-fast accelerations	Light session: 5 × 15 s fast / 60 s walk; mobility and technique	Low–moderate

The third session of each week included 8–10 minutes of handball-specific passing and footwork (CTG) or movement drills (HIITG). No hard session was scheduled within 48 hours of the post-test. The control group continued its usual college routine, and its regular activity was recorded.

E. Statistical analysis

Descriptive statistics (mean and standard deviation) were computed for each group. Pre- to post-test change within each group was tested with the paired-samples t-test. Equivalence of groups at baseline and differences among groups at post-test were examined with one-way analysis of variance (ANOVA). Because the groups were equivalent at baseline, the main comparison used the change score (pre minus post; positive values indicate faster times). Variances of the change scores were unequal (Levene's test, $p < 0.001$), so Welch's ANOVA was used, followed by pairwise Welch t-tests with Bonferroni correction; Tukey's HSD gave the same conclusions. An analysis of covariance was not used because the regression slopes of the groups were not homogeneous. Effect size was expressed as eta squared (η^2). The level of significance was fixed at 0.05. Analyses were performed in Python (SciPy and statsmodels).

V. RESULTS

Table 3. Baseline equivalence of the groups (one-way ANOVA on pre-test scores)

Variable	CTG (Mean ± SD)	HIITG (Mean ± SD)	CG (Mean ± SD)	F (df = 2, 87)	p
Speed (s)	7.436 ± 0.177	7.439 ± 0.173	7.439 ± 0.175	0.004	0.996
Agility (s)	10.166 ± 0.249	10.172 ± 0.252	10.167 ± 0.253	0.005	0.995

The three groups were statistically equivalent at the start of the study.

Table 4. Pre-test and post-test means, mean change and paired t-test results (n = 30 per group)

Variable	Group	Pre-test (Mean ± SD)	Post-test (Mean ± SD)	Mean change (s)	Change (%)	t (df = 29)	p
Speed (s)	CTG	7.436 ± 0.177	7.163 ± 0.137	0.273	3.67	29.40	< 0.001
Speed (s)	HIITG	7.439 ± 0.173	7.211 ± 0.152	0.228	3.06	52.54	< 0.001
Speed (s)	CG	7.439 ± 0.175	7.415 ± 0.169	0.024	0.32	16.03	< 0.001
Agility (s)	CTG	10.166 ± 0.249	9.741 ± 0.157	0.425	4.18	22.41	< 0.001
Agility (s)	HIITG	10.172 ± 0.252	9.822 ± 0.171	0.350	3.44	23.24	< 0.001
Agility (s)	CG	10.167 ± 0.253	10.129 ± 0.242	0.038	0.37	17.71	< 0.001

All three groups showed statistically significant reductions in time. However, the change in the control group was very small (0.024 s in speed and 0.038 s in agility) compared with the experimental groups.

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Table 5. Comparison of change scores among groups (Welch's one-way ANOVA)

Variable	Group	Mean change ± SD (s)	Welch F	p	η^2
Speed	CTG	0.273 ± 0.051	F(2, 43.5) = 1268.41	< 0.001	0.92
	HIITG	0.228 ± 0.024			
	CG	0.024 ± 0.008			
Agility	CTG	0.425 ± 0.104	F(2, 39.9) = 403.62	< 0.001	0.83
	HIITG	0.350 ± 0.083			
	CG	0.038 ± 0.012			

The standard one-way ANOVA on the change scores gave the same conclusion (speed F(2, 87) = 493.65; agility F(2, 87) = 214.09; both $p < 0.001$). Post-test scores also differed among groups (speed F = 22.94; agility F = 33.60; both $p < 0.001$).

Table 6. Pairwise comparisons of change scores (Welch t-test, Bonferroni-adjusted)

Variable	Comparison	Mean difference (s)	t	Adjusted p
Speed	CTG vs CG	0.249	26.52	< 0.001
Speed	HIITG vs CG	0.204	44.56	< 0.001
Speed	CTG vs HIITG	0.045	4.42	< 0.001
Agility	CTG vs CG	0.387	20.29	< 0.001
Agility	HIITG vs CG	0.313	20.54	< 0.001
Agility	CTG vs HIITG	0.074	3.07	0.010

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

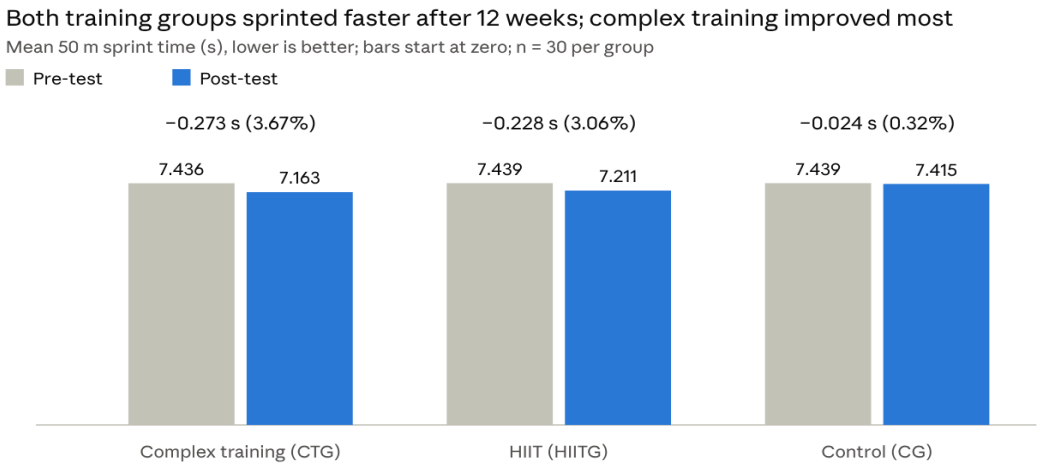


Figure 1. *Pre-test and post-test mean 50 m sprint time (s) of the three groups.*

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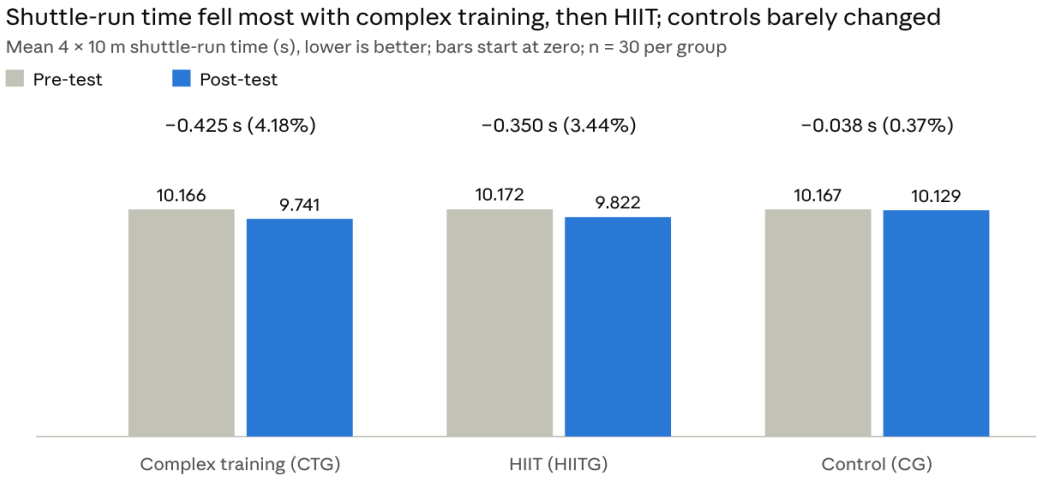


Figure 2. *Pre-test and post-test mean 4 × 10 m shuttle-run time (s) of the three groups.*

VI. DISCUSSION

The aim of this study was to compare complex training and HIIT with a control condition for developing speed and agility in college handball players. The three groups began with virtually identical values, so the differences observed at the end of the 12 weeks can reasonably be linked to the way each group trained.

Both experimental groups became significantly faster over the 50 m sprint and the 4 × 10 m shuttle, which supports hypotheses H1, H2 and H3. The control group improved by only a few hundredths of a second, which is within what might be expected from test familiarity and habitual activity, and was far smaller than the change in either trained group.

The larger improvement in the complex training group agrees with the view that combining heavy lower-body strength work with jumps and short accelerations develops both force production and the ability to apply force rapidly, two qualities that determine acceleration and change of direction (Young et al., 2002; Seitz, de Villarreal & Haff, 2014). Meta-analytic evidence in team sports similarly suggests that complex training can enhance sprint and change-of-direction performance (Freitas et al., 2017; Cormier et al., 2020). Studies of resistance training in handball players have also reported improved sprint performance (Hermassi, Chelly, Tabka, Shephard & Chamari, 2011).

The gains of the HIIT group are consistent with research showing that repeated high-intensity efforts impose substantial neuromuscular load in addition to a metabolic stimulus (Buchheit & Laursen, 2013b). Short sprints and shuttle runs with changes of direction practise the very movements assessed by the tests, and similar benefits of interval-based conditioning have been reported in young team-sport athletes (Sperlich et al., 2011). The somewhat smaller change compared with complex training may be explained by the absence of heavy loading in the HIIT programme, which provides less stimulus for maximal strength and power.

The practical message is that both methods are worthwhile, but when the primary goal is to improve sprinting and agility, a complex training emphasis offers an additional advantage. Because HIIT is simple to organise with minimal equipment, it can be a useful alternative or supplement where resources are limited.

Limitations. The study was restricted to male players from colleges in one city, included only two performance measures, and did not follow participants after the intervention to see whether gains were retained. The training volume of the control group outside the study was recorded but not manipulated. The very small within-group variability of change scores produced large effect sizes, and replication in other samples is advisable.

VII. CONCLUSION

Within the limits of this study, it is concluded that twelve weeks of complex training and of high-intensity interval training, each performed three times a week, significantly improved speed and agility of male college handball players compared with a control group. Complex training produced significantly larger improvements than HIIT in both variables. The research hypotheses H1 to H4 are accepted and the null hypotheses are rejected at the 0.05 level.

VIII. RECOMMENDATIONS

1) Coaches may include periodised complex training in the preparation of college handball players to improve sprinting and agility.
2) HIIT based on short sprints and shuttles may be used where equipment is limited or as a complement to strength-based work.
3) Future studies may include female players, other age groups, additional variables such as jump height, balance and muscular endurance, and a follow-up test to examine retention of gains.

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