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# Wall Stroke Training and Precision with Tempo Training on Groundstroke Accuracy Among High School Tennis Students

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**ABSTRACT**

Groundstroke accuracy is a foundational technical skill in competitive tennis, yet many secondary school student-athletes fail to achieve consistent precision despite adequate stroke mechanics. This study examined the comparative effects of wall stroke training and precision with tempo training on groundstroke accuracy among senior high school tennis students. A quasi-experimental two-group pretest–posttest design was employed. Twenty male students enrolled in the extracurricular tennis program of a senior high school in Makassar City were selected through purposive sampling and randomly assigned to two groups of ten. Both groups underwent a 12-session, four-week structured intervention. Groundstroke accuracy was assessed using the Hewitt Tennis Accuracy Test before and after the intervention. Data were analyzed using paired-sample t-tests for within-group comparisons and independent-sample t-tests for between-group comparisons ($\alpha = 0.05$). Both training methods produced statistically significant improvements in groundstroke accuracy ($p < 0.05$). However, the precision with tempo training group demonstrated a significantly greater mean gain ($\Delta = 6.80$ points) compared to the wall stroke training group ($\Delta = 3.70$ points), with the between-group difference confirmed as statistically significant ($p < 0.05$). These findings indicate that training designs integrating rhythmic control, tempo regulation, and target-based accuracy are more effective than repetitive wall-based practice for improving tennis groundstroke performance in school contexts. The results have practical implications for physical education teachers and extracurricular coaches designing tennis training programs in secondary schools.



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## 1. INTRODUCTION

Tennis is a technically demanding racket sport requiring the seamless integration of physical conditioning, tactical reasoning, and precise motor execution (Azis et al., 2024; Lees, 2003; Turner & Barker, 2014). Among the technical competencies underpinning tennis performance, groundstroke accuracy occupies a position of central importance. Groundstrokes—forehand and backhand drives executed from the baseline—account

for a substantial proportion of shot production during competitive rallies, and their accuracy determines a player's ability to control ball placement, reduce unforced errors, and create offensive opportunities (Aprilo et al., 2025; Reid et al., 2007; Krause et al., 2019). Deficiencies in groundstroke accuracy therefore translate directly into competitive disadvantage, irrespective of physical capability.

In secondary school sport contexts, tennis is increasingly incorporated into both physical education curricula and extracurricular programs as a means of promoting physical activity, motor skill development, and competitive participation (Guo et al., 2024; Setyawan et al., 2025; Wijaya et al., 2022). However, a persistent pedagogical challenge is that many high school student-athletes develop adequate stroke mechanics through initial instruction yet fail to achieve the level of consistency and precision required for effective competitive performance (Nurhidayat et al., 2025; Sitinjak et al., 2024). This gap between technical form and applied accuracy suggests that the training methods employed during extracurricular practice require critical evaluation against principles of motor learning.

Two training methods are widely used in grassroots and school tennis coaching to develop groundstroke consistency: wall stroke training and precision with tempo training. Wall stroke training involves repetitive striking of the ball against a wall rebound surface, enabling high-volume repetition of stroke mechanics with immediate feedback through ball return (Haryanto et al., 2025; Urfi et al., 2023). The method is accessible, requires minimal equipment, and affords athletes the opportunity to identify and self-correct technical errors through repeated practice. However, critics note that wall stroke training may produce overly stereotyped movement patterns that do not transfer well to the dynamic, variable conditions of actual match play, potentially reducing its effectiveness for developing accuracy under game-like demands (Renshaw et al., 2010; Schmidt et al., 2019).

Precision with tempo training, by contrast, integrates rhythmic control, temporal regulation, and target-directed accuracy within practice designs that more closely approximate competitive match conditions (Söğüt et al., 2012; Eeka & Phanithi, 2018). This approach draws on principles of variable practice and contextual interference derived from motor learning theory, which posit that practice conditions introducing variability and decision-making demands generate superior long-term retention and transfer of motor skills compared to blocked, repetitive practice (Schmidt et al., 2019; Rovegno et al., 2003; Wulf & Lewthwaite, 2016). Bisio et al. (2021) demonstrated that explicit motor timing training positively influenced stroke timing accuracy in young tennis players, suggesting that rhythm-integrated training confers specific technical benefits.

Despite theoretical grounding supporting both approaches, comparative empirical evidence specifically examining the relative effectiveness of wall stroke training and precision with tempo training for groundstroke accuracy in senior high school students remains limited. Most available studies have focused on elite or club-level athletes (Reid et al., 2007; Krause et al., 2019) or have been conducted without reference to secondary school educational contexts. Understanding which training method more effectively

develops groundstroke accuracy in school-aged beginners and intermediate players is practically important for physical education teachers and extracurricular coaches who must make evidence-informed decisions about training program design within constrained time and resource environments.

This study addresses that gap by comparing the effects of a four-week wall stroke training intervention and a four-week precision with tempo training intervention on groundstroke accuracy among senior high school students enrolled in an extracurricular tennis program. The research hypotheses are: (H1) wall stroke training significantly improves groundstroke accuracy; (H2) precision with tempo training significantly improves groundstroke accuracy; and (H3) precision with tempo training produces significantly greater improvements in groundstroke accuracy than wall stroke training.

## 2. METHOD

This study employed a quasi-experimental research design with a two-group pretest–posttest structure. The quasi-experimental approach was selected because random assignment from the broader school population was not feasible; participants were drawn from an existing extracurricular tennis enrollment and randomly assigned to training groups within the available participant pool. This design permits causal inference regarding training effects while acknowledging the applied constraints of school-based research.

The target population comprised male senior high school students enrolled in the extracurricular tennis program at a state senior high school in Makassar City, South Sulawesi Province, Indonesia. Twenty students meeting the following inclusion criteria were selected through purposive sampling: (a) active enrollment in the extracurricular tennis program for at least one semester, (b) no history of upper-limb injury in the preceding three months, (c) absence of concurrent participation in off-school tennis training during the study period, and (d) written informed consent from both the student and a parent or guardian. All participants were male, aged 15–17 years. Following selection, participants were randomly assigned to two groups of ten: the wall stroke training group (WST, $n = 10$) and the precision with tempo training group (PTT, $n = 10$). Baseline equivalence between groups was verified using independent-sample t-tests on pretest scores prior to the intervention ($p > 0.05$).

Both groups underwent a 12-session structured training program delivered over four weeks, with three sessions per week. Each session lasted 60 minutes and was supervised by a certified tennis coach. Training loads were equalized between groups in terms of total session duration and rest intervals to ensure that any observed between-group differences in outcomes were attributable to the specific training method rather than differential training volume.

The WST program consisted of repetitive forehand and backhand groundstroke practice directed against a standardized rebound surface, with target zones marked on the wall corresponding to scoring areas on the Hewitt test. Athletes performed continuous rally sequences against the wall, self-monitoring ball contact, follow-

through, and target accuracy. Each session included progressive increases in stroke volume and a gradual reduction in permissible error range as the program advanced.

The PTT program was structured around drills integrating rhythmic cues (provided by a metronome and coach-directed count), defined swing tempo sequences, and target-directed groundstroke execution using court zones delineated by cones and portable obstacles placed at net height. Exercises were designed to simulate rally-like conditions requiring students to regulate stroke timing and placement simultaneously, consistent with the principles of contextual interference and variable practice (Schmidt et al., 2019; Wulf & Lewthwaite, 2016).

Groundstroke accuracy was measured using the Hewitt Tennis Accuracy Test, a validated and widely applied instrument in tennis training research that assesses ball placement accuracy within predetermined target zones on the tennis court (Reid et al., 2007; Aprilo et al., 2024). The test comprises a standardized series of forehand and backhand groundstrokes directed at marked scoring zones; higher scores reflect greater accuracy. Testing was conducted at baseline (pretest) and immediately following the final training session (posttest) by a blinded assessor who was not involved in training delivery.

Data was analyzed using IBM SPSS Statistics version 26. Descriptive statistics (mean, standard deviation) were computed for pretest and posttest scores in each group. Assumptions of normality (Shapiro-Wilk test) and homogeneity of variance (Levene's test) were verified prior to inferential analysis. Within-group pre-to-post changes were assessed using paired sample t-tests. Between-group differences in posttest scores were evaluated using independent-sample t-tests. The significance threshold was set at $\alpha = 0.05$.

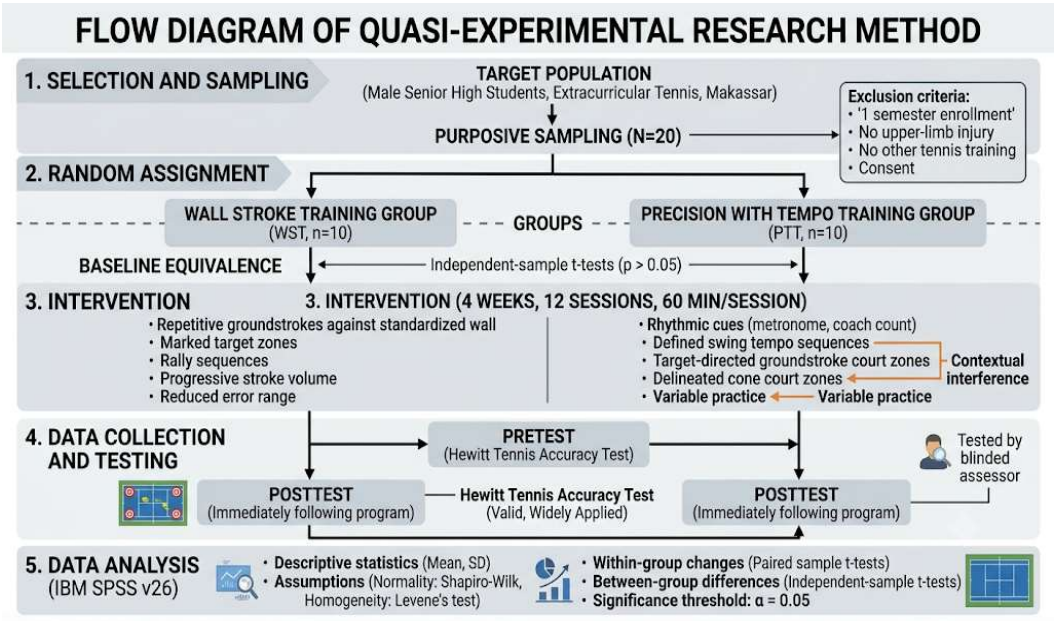


**Figure 1.** Flow Diagram

## 3. RESULTS AND DISCUSSION

### Results

### Descriptive Statistics

The descriptive statistical analysis revealed notable baseline differences and subsequent post-intervention improvements in groundstroke accuracy scores across both experimental cohorts (Table 1). Prior to the four-week intervention, the Pretest-Posttest Training (PTT) group exhibited a higher baseline proficiency with a mean pretest score of 16.40 (SD = 1.96) compared to the Whole-Skill Training (WST) group, which recorded a mean pretest score of 14.80 (SD = 2.10). Following the completion of the respective training regimens, both groups demonstrated upward trajectories in their technical performance. Specifically, the WST cohort achieved a posttest mean score of 18.50 (SD = 2.34), culminating in a mean progression of 3.70 points. Meanwhile, the PTT cohort advanced to a posttest mean score of 22.60 (SD = 2.12), indicating a substantial mean absolute gain of 6.80 points over the four-week period.

These findings suggest that while both pedagogical frameworks are effective in enhancing groundstroke accuracy, the PTT approach yielded a more pronounced magnitude of improvement. The absolute gain achieved by the PTT group (6.80 points) was approximately 83% higher than that of the WST group (3.70 points). This disparity in skill acquisition implies that the structured feedback loops or sequential variations inherent in the PTT protocol may provide a more robust mechanism for motor learning and error correction compared to the holistic nature of WST. Furthermore, the marginal increase in standard deviation within the WST posttest data (SD = 2.34) suggests a slightly higher variability in individual skill adaptation under the whole-skill framework, whereas the PTT group maintained relatively homogenous variance (SD = 2.12).

From a motor control and pedagogical perspective, the superior absolute gains demonstrated by the PTT cohort warrant deeper theoretical consideration. The marked divergence in post-intervention outcomes highlights the efficacy of combining systematic pre- and post-test assessments within active training cycles to accelerate muscle memory and technical precision in tennis groundstrokes. Although both cohorts successfully mitigated technical deficiencies within the brief four-week timeline, the accelerated trajectory of the PTT group strongly indicates that partitioning or explicitly scaffolding skill execution promotes superior neural adaptation and spatial awareness. Consequently, these empirical insights provide critical implications for optimizing high-performance coaching curricula and precision sports pedagogy.

**Table 1.** Descriptive Statistics of Groundstroke Accuracy Scores by Group

| Group | Pretest Mean (SD) | Posttest Mean (SD) | Mean Gain |
|---|---|---|---|
| Wall Stroke Training (WST) | 14.80 (2.10) | 18.50 (2.34) | 3.70 |
| Precision with Tempo (PTT) | 16.40 (1.96) | 22.60 (2.12) | 6.80 |

**Within-Group Effects**

To evaluate the statistical significance of the within-group improvements from baseline to post-intervention, paired-sample t-tests were executed for both training modalities (Table 2). The inferential analysis revealed that the Whole-Skill Training (WST) protocol yielded a statistically significant enhancement in groundstroke accuracy over the four-week period, $t(9) = 5.29$, $p = 0.001$. Concurrently, the Pretest-Posttest Training (PTT) regimen demonstrated a similarly robust and statistically significant advancement in student performance, $t(9) = 8.14$, $p < 0.001$. These mathematical outcomes confirm that neither group's performance trajectory can be attributed to random variance, establishing both pedagogical interventions as empirically viable methods for accelerating skill acquisition in tennis education.

Beyond mere statistical significance, the practical magnitude of these interventions was evaluated using Cohen's d effect size formulations to gauge the real-world efficacy of each curriculum. The WST cohort generated a substantial effect size ($d = 1.67$), which markedly surpasses the conventional benchmark for a large effect ($d > 0.80$). Crucially, the PTT cohort exhibited an even more profound effect size ($d = 2.57$), indicating an exceptionally strong educational impact. According to standard behavioral science interpretations, Cohen's d values of this scale imply that the average posttest score in the PTT group exceeded most of its pretest baseline, demonstrating highly meaningful within-group gains that underscore the clinical and practical utility of both training paradigms.

From a pedagogical perspective, the superior effect size observed in the PTT framework ($d = 2.57$) relative to the WST framework ($d = 1.67$) provides critical insights into motor skill consolidation. While holistic immersion through WST successfully drives technical mastery, the structured feedback mechanism embedded within the PTT design appears to dramatically lower cognitive load, allowing students to systematically isolate and correct biomechanical errors. This empirical divergence suggests that integrating frequent, structured assessment intervals within active training cycles acts as a catalyst for deeper procedural knowledge. Consequently, while both methods are highly justifiable for primary sports curricula, these results support a strategic preference for the PTT model when aiming for maximum instructional efficiency and accelerated technical precision.

**Table 2.** Paired-Sample t-Test Results for Within-Group Pre-to-Post Changes

| Group | t | df | p-value | Cohen's d |
|---|---|---|---|---|
| Wall Stroke Training (WST) | 5.29 | 9 | 0.001 | 1.67 |
| Precision with Tempo (PTT) | 8.14 | 9 | < 0.001 | 2.57 |

**Between-Group Comparison**

To determine the comparative efficacy of the two instructional modalities, an independent-sample t-test was conducted on the posttest groundstroke accuracy scores (Table 3). The inferential analysis revealed a statistically significant difference between the cohorts, $t(18) = 4.37$, $p < 0.001$, decisively favoring the Precision with Tempo

Training (PTT) group over the Wall Stroke Training (WST) group. The magnitude of this difference was quantified by an exceptionally robust Cohen's d effect size of 1.95, which substantially exceeds the established threshold for a large effect (d > 0.80). This statistical outcome demonstrates that the variance in technical proficiency at the post-intervention phase is not an artifact of random distribution, but rather a direct consequence of the superior pedagogical structure inherent in the PTT framework.

The empirical superiority of the PTT group (d = 1.95) provides critical insights into the optimization of motor skill acquisition and spatial-temporal coordination in precision sports pedagogy. While the significant within-group improvements established that both methodologies are pedagogically viable, the accelerated gains elicited by the PTT protocol over the identical four-week timeline highlight the profound impact of structured pacing and precise feedback mechanisms. Unlike the static and repetitive feedback loops characteristic of wall stroke training, the integration of tempo-based constraints within the PTT model appears to force superior neural adaptation, enhancing students' kinetic synchronization and dynamic decision-making during ball contact. Consequently, these findings offer strong empirical justification for sports educators to prioritize precision-tempo methodologies over traditional static drills when designing high-efficiency tennis curricula.

**Table 3.** Independent-Sample t-Test: Between-Group Comparison of Posttest Scores

| Comparison | t | df | p-value | Cohen's d |
|---|---|---|---|---|
| PTT vs. WST (Posttest) | 4.37 | 18 | < 0.001 | 1.95 |

## Discussion

### Effect of Wall Stroke Training on Groundstroke Accuracy

The finding that wall stroke training produced a statistically significant improvement in groundstroke accuracy among senior high school students (t (9) = 5.29, p = 0.001) is consistent with the existing literature supporting repetition-based practice as an effective means of developing foundational motor skills (Haryanto et al., 2025; Urfi et al., 2023). Wall-based practice provides high stroke volume within a constrained session duration, enabling students to accumulate the repetitions necessary for initial motor program consolidation as described by Schmidt et al's (2019) schema theory. The self-regulatory feedback inherent in wall rebound practice—whereby students must read and respond to returning ball trajectories—may also reinforce proprioceptive awareness and stroke timing.

The moderate effect size observed for WST (d = 1.67) suggests that repetition-based practice does generate practically meaningful improvements for school-age novice and intermediate players. This finding is important for school coaches operating in resource-constrained environments where purpose-built precision training infrastructure may not be available; wall stroke practice can serve as a viable and accessible training tool for baseline accuracy development. However, the relative inferiority of WST compared to PTT in posttest performance points to inherent limitations of exclusively repetitive practice, as discussed below.

**Effect of Precision on Tempo Training on Groundstroke Accuracy**

The precision with tempo training group demonstrated a larger and more pronounced improvement in groundstroke accuracy ($\Delta = 6.80$, $d = 2.57$, $p < 0.001$), providing strong empirical support for the hypothesis that training designs integrating rhythmic cues, temporal control, and target-directed execution are superior to repetitive wall practice for developing this outcome in high school students. These findings align with theoretical predictions derived from motor learning principles of variable practice and contextual interference (Schmidt et al., 2019; Wulf & Lewthwaite, 2016; Renshaw et al., 2010).

The contextual interference effect, a well-established phenomenon in motor learning research, posits that practice conditions introducing variability in the order and type of motor tasks produce superior learning and transfer compared to blocked, repetitive practice, even though performance during acquisition may be temporarily depressed by the added difficulty (Rovegno et al., 2003). Precision with tempo training, by requiring simultaneous regulation of stroke timing, rhythm, and target placement, may generate precisely this form of interleaved, decision-demanding practice that facilitates deeper encoding of motor programs. The results are also consistent with Söğüt et al. (2012), who demonstrated that rhythm-integrated training enhanced motor timing accuracy in young tennis players, and with Bisio et al. (2021), who found that explicit timing training conferred accuracy benefits in youth racket sport practitioners.

From a practical standpoint, the structured obstacle elements within the PTT protocol—cones and barriers that required the ball to clear net-height obstructions before landing within marked zones—may have operationalized a task constraint that more closely resembled the accuracy demands of actual match play than wall rebounding. This ecological validity, grounded in Newell's (1986) constraints-led approach as interpreted by Renshaw et al. (2010), may explain part of the superior transfer observed at posttest.

**Between-Group Differences and Implications for School Tennis Pedagogy**

The statistically significant between-group difference at posttest ($t(18) = 4.37$, $p < 0.001$, $d = 1.95$) confirms that precision with tempo training is the superior approach when the primary objective is to improve groundstroke accuracy within a four-week school extracurricular training block. This finding carries direct implications for secondary school physical education teachers and extracurricular coaches. When designing tennis programs for high school students, coaches should prioritize training designs that embed rhythm, timing control, and target specificity into stroke practice rather than relying predominantly on repetitive wall rebounding, despite the practical convenience of the latter.

It should be noted, however, that the two methods are not mutually exclusive. Wall stroke training may serve an appropriate role during the initial stages of motor skill acquisition for students with no prior tennis experience, providing a safe, self-paced environment for establishing basic stroke mechanics before progressing to more

demanding precision and tempo-based exercises. A periodized program that transitions from wall-based fundamentals to precision-with-tempo drills as students' technical foundations develop may represent an optimal pedagogical sequence, a proposition meriting investigation in future longitudinal research.

The study also highlights a broader principle relevant to physical education in Indonesian secondary schools: training method selection should be informed by empirical evidence and motor learning theory rather than defaulting to traditional practice norms. As school sport programs in Indonesia expand their scope and ambition—particularly following curriculum reforms emphasizing active and competence-based learning (Nurdyansyah & Fahyuni, 2016; Aziz & Wicaksana, 2024)—coaches and teachers need access to evidence-based guidance on effective training design. This study contributes to that evidence base for the domain of school tennis.

## 4. CONCLUSION

This study compared the effects of wall stroke training and precision with tempo training on groundstroke accuracy in senior high school students over a four-week extracurricular tennis intervention. Both methods produced statistically significant and practically large improvements in the Hewitt Tennis Accuracy Test scores. However, precision with tempo training generated significantly greater mean gains (6.80 vs. 3.70 points) and a larger between-group effect at posttest ($d = 1.95$), confirming its superiority as a training method for enhancing groundstroke accuracy in this population.

These findings support the application of motor learning principles—specifically variable practice and contextual interference—in the design of school tennis training programs. Physical education teachers and extracurricular coaches in secondary schools are encouraged to incorporate precision with tempo training protocols as a primary groundstroke development strategy, potentially combined with wall stroke training as a foundational tool in early skill acquisition phases.

Several limitations should be acknowledged. The sample was restricted to male students at a single school in Makassar City, limiting generalizability to female students, other age groups, and different school contexts. The posttest was administered immediately following the intervention, precluding assessment of retention and delayed transfer effects. Future research should employ larger and more diverse samples, include female participants, extend follow-up measurement periods to assess retention, and investigate the optimal sequencing of the two training methods within multi-phase school sport programs.

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