DOI: 10.7860/JCDR/2026/79392.22449

Effect of Low versus High Level Task Difficulty Balance Training on Dynamic Postural Control, Speed and Skating Performance in Young Roller Skaters: A Comparative Study

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ABSTRACT

Introduction: Roller skating is a complex sport requiring high levels of dynamic balance, coordination, agility, speed and postural control. Training methods that enhance these attributes are crucial for improving skating performance and preventing injuries. Task Difficulty Balance Training (TDBT) has shown promise in enhancing neuromuscular control, but its specific impact on roller skaters remains underexplored.

Aim: The present study aimed to compare the effects of low and high task difficulty balance training on dynamic postural control, speed, and roller skating performance in young athletes.

Materials and Methods: The present comparative study was conducted at Sprint skating academy, Pimpri, Pune, Maharashtra, India during the 2023-2025 academic period. Sixty roller skaters (aged 10 to 15 years) were randomly assigned to two groups: Group A (Low Task Difficulty Balance Training (LTDBT) and Group B High Task Difficulty Balance Training (LTDBT). Both groups completed a 5-week training program (three sessions per week) with progressive balance exercises. Pre and post-training assessments included the Roller Skating Performance Test, Arrowhead Change of Direction Speed Test, and Modified Star Excursion Balance Test (mSEBT). Statistical analyses were performed using Wilcoxon Signed Rank and Mann-Whitney U tests.

Results: Both groups showed significant improvements in roller skating performance, speed, and dynamic balance ($p<0.05$). However, the high task difficulty group exhibited superior improvements in performance time (6.14±1.27 vs. 3.60±0.88sec), speed (Arrowhead test: 2.32±0.52s vs. 1.34±0.54s), and dynamic balance (mSEBT reach distance, $p<0.05$). Intergroup analysis showed significant differences favouring high task difficulty training, except for mSEBT right-leg performance ($p>0.05$).

Conclusion: TDBT enhances dynamic postural control, speed, and skating performance. High task difficulty balance training yields greater benefits, emphasizing the need for progressive balance exercises in roller skating programs to optimize performance and injury prevention.

Keywords: Balance training, Postural control, Roller skating,Speed,Task difficulty

INTRODUCTION

Exercise and sports are essential for a healthy lifestyle, enhancing physical health, illness resistance, and psychological well-being. Athletic and cognitive skills in young athletes develop progressively through individual performance. Engaging in various sports improves coordination, neuromuscular function, and overall health [1]. Research indicates that agility, balance, and coordination are built upon basic skills, evolving as children's skeletal and neurological systems mature. Early exposure to motor learning within appropriate age ranges enhances sport performance by refining sensory and motor systems [2,3].

Roller skating has gained popularity among children and requires precise biomechanical control across various motion phases: propulsion (push-off), glide, recovery, turning and crossovers, and stopping [4-8]. It demands athletic abilities such as speed, balance, coordination, and agility. Speed is the ability to move swiftly in a specific direction, while agility involves rapid acceleration, deceleration, and directional changes. The crouched position in skating minimises air resistance, enhancing speed and stability [9-12].

Skating challenges postural control mechanisms, requiring dynamic balance adjustments through hip, ankle, and knee responses. Sensory inputs-visual, proprioceptive, and vestibular play crucial roles in maintaining balance [5,13]. Postural control ensures stability by integrating neural signals that detect and correct imbalances [14]. Research highlights cortical activity during balance regulation, particularly in the anterior cingulate, dorsolateral prefrontal cortex, and supplementary motor areas [15]. Theta frequency band changes, especially in frontocentral areas, contribute to identifying postural errors and guiding corrective actions [7].

As competitive levels rise, athletes face greater physical demands, increasing injury risk. Lower limb injuries, particularly overuse injuries in the landing and takeoff legs, are prevalent in skaters, with an incidence rate of approximately 60% [6]. Conditioning programs must include proprioception and balance training to prevent injuries and enhance performance. However, many youth coaches lack the expertise to implement comprehensive training, often focusing solely on sport-specific skills, leading to chronic overuse injuries due to inadequate training and recovery [16].

Numerous original studies have demonstrated the efficacy of task difficulty balance training (BT) in enhancing various aspects of balance ability in children and adolescents, and these results have been consolidated in systematic reviews [17]. Methods such as reducing the base of support, modifying sensory input, and introducing cognitive-motor interference enhance postural control. Increased task complexity, such as standing on unstable surfaces or closing the eyes, induces cortical adaptations that improve balance. Despite the biomechanical demands of roller skating, limited research has examined specialized training approaches for enhancing balance and motor control. Existing studies primarily address talent identification rather than investigating the direct effects of balance training on skating performance [18].

Task difficulty balance training has been recognized as a crucial element in athletic development, aiding in postural control, movement efficiency, and injury prevention. However, there is a gap in understanding the effects of varying levels of task difficulty balance training on roller skaters. The present study aimed to assess the impact of high- and low-task difficulty balance training on young roller skaters' balance, speed, and overall performance. By examining these training approaches, the investigators seek to provide evidence-based insights to help coaches design more effective training regimens. Understanding how different levels of balance training influence performance will contribute to structured, scientifically based programs for young skaters. We hypothesize that both training protocols will improve dynamic postural control, speed and skating performance, but with greater enhancements in the high-task difficulty training group.

MATERIALS AND METHODS

The present comparative study was conducted at Sprint skating academy, Pimpri, Pune, Maharashtra, India during the 2023-2025 academic period. Sixty roller skaters were recruited using simple random sampling. Ethical approval was obtained from the Institutional Ethics Committee (IEC ref. no. DYPCPT/IEC/39/2024) and registered under CTRI (CTRI/2024/04/065987), ensuring adherence to ethical guidelines.

Inclusion and Exclusion criteria: Participants aged 10-15 years, actively engaged in skating for over two months, were included. Those with musculoskeletal injuries in the past six months, systemic disorders, or neurological impairments affecting performance were excluded.

Sample Size Calculation

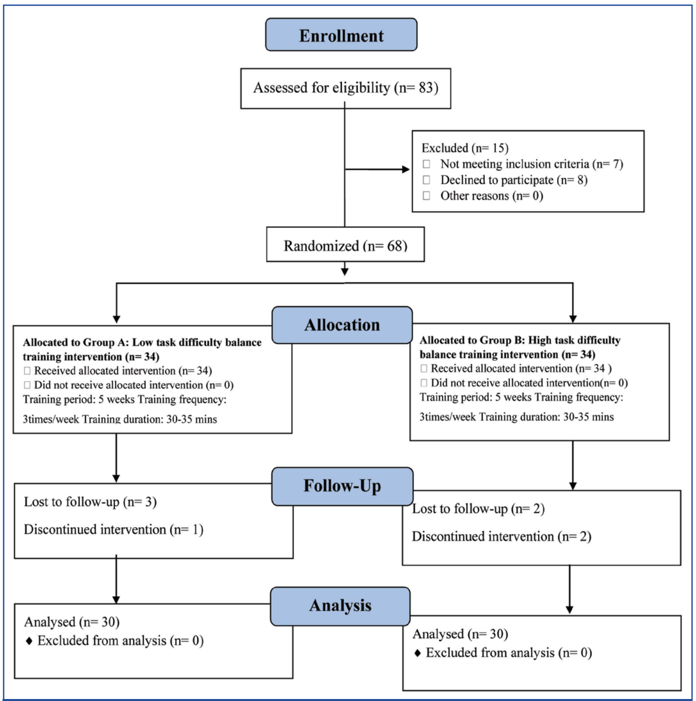
The sample size was calculated using WinPepi statistical software (version 11.65). With 99% power and a 5% significance level, the minimum required sample size was determined to be 60 participants, with 30 allocated to group A (LLTDBT) and 30 to group B (HLTDBT).

Study Procedure

Eighty-three skaters were assessed, with 68 meeting the criteria. They were randomly divided into group A (Low task difficulty balance training) and group B (High task difficulty balance training). Four from group A and four from group B dropped out due to injuries or personal reasons. The study followed CONSORT guidelines [19], with recruitment beginning in June 2024, and assessments and interventions conducted thereafter. Written informed consent from parents and assent from participants were obtained [Table/Fig-1].

Pre and post-testing occurred at the academy before and after five weeks of training. A standard warm-up was conducted prior to tests, with a 5-minute rest between trials. Each test was performed thrice, with the best score recorded. The testing was conducted with careful consideration and adherence to standardized procedures to ensure accuracy and reliability.

Intervention: Both groups underwent a 5-week training program (3 sessions/week, 30-35 mins/session), including six exercises per session. Each exercise was performed for 30-sec (2 sets), with 1-min rest between sets and 3-min rest between exercises. Training began with a 10-min warm-up (jogging, jumps, lunges, stretching) and ended with a 15-min cool-down (stretching, light jogging). Group A performed low-difficulty balance exercises as shown in [Table/Fig-2,3], while group B performed higher-difficulty versions as shown in [Table/Fig-4,5] with identical training volume. Progression was achieved by modifying stance (two-legged, tandem, single-leg), altering visual conditions (eyes open/closed), and adding cognitive or physical tasks (e.g., ball-catching, backward counting) [17]



[Table/Fig-1]: Consolidated Standards of Reporting Trials (CONSORT) showing the recruitment, inclusion, exclusion, randomization, and analysis of participants

Outcome Measures

1. Primary-Roller Skating Performance Test -Used to assess Skating Performance
2. Secondary- Arrowhead Change of Direction Speed Test -Used to assess speed and agility
3. Secondary Modifi ed Star Excursion Balance Test -Used to assess Dynamic Postural Control

Modified Star Excursion Balance Test (mSEBT, ICC 0.87–0.93) [20-22]

Assessed dynamic postural control using a Y-shaped grid with anterior (ANT), posterolateral (PL), and posteromedial (PM) reach directions according to standard procedures [18-20]. Participants stood barefoot and balanced on one leg, reaching the three directions while maintaining stability. Reach distance was measured from the start position in centimeters. Each participant completed six trials-three for left leg, followed by three for right leg and an average of the readings were taken [Table/Fig-6].

Arrowhead Change of Direction Speed Test (ICC=0.92–0.93) [23]

Evaluated speed and agility using a cone-based sprint test according to standard procedures [23]. Participants ran from a start line, sprinted around markers, and returned, with time required to complete the test was recorded using stopwatch in seconds. Each participant completed six trials-three to the left, followed by three to the right and the best score was taken [Table/Fig-7].

Roller Skating Performance Test (ICCs=0.70) [24]

Assessed skating performance according to standard procedures, including key skills like starting, circling, S-turns, push-offs, acceleration, and parallel skating through cones [22]. Performance time was recorded via stopwatch in seconds. Each participant completed three trials and the best score was taken [Table/Fig-8].

STATISTICAL ANALYSIS

Data analysis used Statistical Package for Social Sciences (SPSS) 27.0 and GraphPad Prism 7.0. Continuous data were reported as mean±SD, categorical data as frequencies and percentages.

Sessions	Exercise 1 on Balance Pad	Exercise 2 on Ankle Disc	Exercise 3 on Balance Board	Exercise 4 on Air Cushion	Exercise 5 on Balance Beam	Exercise 6
Session 1 and 2	Tandem Stance with eyes open and with arm support	2 leg stance with eyes open and with arm support	2 leg stance with eyes open and with arm support	1 leg stance with eyes open and arm support	Walking forward: eyes opened, with arm support (without balance beam)	Tandem Walking forward between 2 lines with eyes open and with arm support
Session 3 and 4	1 leg stance with eyes open and arm support	2 leg stance with eyes open and without arm support	2 leg stance with eyes open and without arm support	1 leg stance with eyes open and without arm support	Walking forward: eyes opened, without arm support	Tandem walking forwards on one line with eyes open and arm support
Session 5 and 6	1 leg stance with eyes open and arm support	2 leg stance in squatting position with eyes open and with arm support	2 leg stance with eyes open and with arm support	Flamingo stance: eyes opened, with arm support (without Air cushion)	Walking backwards with eyes open and with arm support	One-legged stance: change from eyes opened to close every 5 seconds
Session 7 and 8	2 leg stance with squatting position with eyes open and arm support	2 leg stance in squatting position with eyes open and with arm support	2 leg stance with eyes open and with arm support	2 leg stance in squatting position with eyes open and with arm support	Walking backwards with eyes open and with arm support	Flamingo stance with eyes open and without arm support
Session 9 and 10	2 leg stance with squats with eyes open and without arm support	1 leg stance and 2 leg stance squats with eyes open and with arm support	2 leg stance in squatting position with eyes open and with arm support		Walking backwards with eyes closed and without arm support	One leg stance squat with eyes closed and without arm support
Session 11 and 12	1 leg stance with eyes closed and arm support	2 leg stance squats with eyes open and with arm support Flamingo stance: eyes opened, with arm support	2 leg stance squats with eyes open and with arm support		Walking backwards with eyes open and with arm support counting backwards	Y balance reach with eyes open and with arm support
Session 13 and 14	1 leg stance with eyes closed and without arm support	2 leg stance squats with eyes open and with arm support	2 leg stance squats with eyes closed and with arm support		Walking backwards with eyes open and with arm support counting backwards	Y balance reach with eyes closed and with arm support One-legged stance: squats, eyes opened, with arm support

[Table/Fig-2]: Low level of task difficulty balance training

[Table/Fig-3]: Participant performing different exercises according to the sessions mentioned above in the low level of task difficulty balance training
3a: Flamingo stance with eyes open and with arm support
3b: 2 leg stance with eyes open and with arm support on balance board
3c: 1 leg stance with eyes open and arm support on air cushion
3d: 2 leg stance with eyes open and with arm support on Ankle disc
3e: 1 leg stance with eyes open and arm support on balance pad
3f: 2 leg stance in squatting position with eyes open and with arm support on ankle disc
3g: Tandem Stance with eyes open and with arm support on balance pad
3h: Walking forward: eyes opened, without arm support on balance beam

Statistical tests included Chi-square, Shapiro-Wilk for normality, Wilcoxon Signed Rank for intra-group, and Mann-Whitney U for inter-group comparisons. A p-value <0.05 was considered significant, ensuring robust and clinically relevant results.

RESULTS

In this comparative study 60 participants, were divided into group A (Low-level TDBT, n=34; age: 12.26±1.55 years; Body Mass Index (BMI) 21.49±2.84 kg/m²) and group B (High-level TDBT, n=34; age: 12.20±1.73 years; BMI: 22.47±4.03 kg/m²) as shown in the [Table/Fig-9] through simple random sampling, intra-group analysis using the Wilcoxon Signed Rank test and inter-group comparisons using the Mann Whitney U test revealed significant improvements in both groups. group A demonstrated a notable enhancement in roller skating performance, with RSP time decreasing from 36.01 to 32.41 seconds, speed time improving from 14.98 to 13.63 seconds (right) and from 14.75 to 13.49 seconds (left), and dynamic balance increasing from 100.40 to 112.55 cm (right) and from 98.13 to 106.76 cm (left). This reflected that the differences were statistically significant with p-value <0.001 [Table/Fig-10,11]. Similarly, group B exhibited a greater improvement, with RSP time reducing from 36.12 to 29.97 seconds, speed time decreasing from 14.69 to 12.37 seconds (right) and from 14.69 to 12.28 seconds (left), and dynamic balance improving from 104.22 to 117.14 cm (right) and from 103.20 to 115.72 cm (left). This also reflected that the differences were statistically significant with p-value <0.001 [Table/Fig-12,13]. Both groups showed statistically significant intra-group improvements (p<0.05), while inter-group analysis revealed that high task difficulty training produced significantly greater gains in performance, speed, and dynamic postural control, except for the right-side SEBT score, which was not statistically significant (p>0.05). These findings indicate that both training approaches are effective in enhancing roller skating performance, though high task difficulty balance training yields comparatively superior outcomes [Table/Fig-14,15].

DISCUSSION

The present study demonstrated that both training protocols significantly improved dynamic postural control, skating performance and speed. However, improvements were more pronounced in the high task difficulty group, showing medium effect sizes compared to small effect sizes in the low difficulty group. Improvements in this

	Exercise 1 on Balance Pad	Exercise 2 on Ankle Disc	Exercise 3 on Balance Board	Exercise 4 on Air Cushion	Exercise 5 on Balance Beam	Exercise 6
Session 1 and 2	Tandem Stance with eyes closed and with arm support	2 leg stance with eyes closed and arm support	2 leg stance with eyes open and arm support	1 leg stance with eyes closed and arm support	Walking forwards with eyes open and with arm support	Tandem Walking forward between 2 lines with eyes open and without arm support
Session 3 and 4	1 leg stance with eyes closed and arm support	2 leg stance with eyes closed and without arm support	2 leg stance with eyes open and without arm support	1 leg stance with eyes closed and without arm support	Walking forwards with eyes open and without arm support	Tandem walking on one line with eyes open and without arm support
Session 5 and 6	1 leg stance with eyes closed and arm support	2 leg stance in squatting position with eyes closed and with arm support	2 leg stance with eyes closed and with arm support	Flamingo stance with eyes closed with arm support (without air cushion)	Walking forwards with eyes open and with arm support and counting backwards	Tandem stance with eyes closed and counting backwards
Session 7 and 8	2 leg stance with squatting position with eyes closed and arm support	2 leg stance in squatting position with eyes closed and with arm support	2 leg stance with eyes open and without arm support	2 leg stance in squatting position with eyes closed and with arm support	Walking forwards with eyes open and with arm support and counting backwards	Flamingo stance with eyes closed without arm support
Session 9 and 10	2 leg stance with squats with eyes closed and without arm support	1 leg stance with eyes open and without arm support	2 leg stance in squatting position with eyes open and with arm support	2 leg stance in squats with eyes closed and with arm support	Walking backwards with eyes closed and without arm support and counting backwards	One leg stance squat with eyes closed and without arm support
Session 11 and 12	1 leg stance with eyes closed and arm support counting backwards	2 leg stance squats with eyes closed and with arm support	2 leg stance squats with eyes open and with arm support	Flamingo stance with eyes open and without arm support	Walking backwards with eyes open with basketball dribbling	Y balance reach with eyes open and without arm support
Session 13 and 14	1 leg stance with eyes closed and without arm support counting backwards	2 leg stance squats with eyes closed and with arm support	2 leg stance squats with eyes closed and with arm support	One leg stance squat with eyes open and with arm support (without air cushion)	Walking backwards with eyes open and throw or catch tennis ball	Y balance reach with eyes closed and without arm support

[Table/Fig-4]: High Level of task difficulty balance training

[Table/Fig-5]: Participant performing different exercises according to the sessions mentioned above in the high level of task difficulty balance training
5a: 2 leg stance with eyes closed and with arm support on Ankle disc
5b: 1 leg stance with eyes closed and arm support on balance pad
5c: 2 leg stance with eyes open and without arm support on balance board
5d: 1 leg stance with eyes closed and without arm support on air cushion
5e: One leg stance squat with eyes closed and without arm support
5f: 1 leg stance with eyes closed and arm support on balance pad
5g: Walking backwards with eyes open with basketball dribbling on balance beam
5h: 2 leg stance with eyes closed and without arm support on ankle disc
14 sessions in 5 weeks of task difficulty balance training were given and all the outcome measures were assessed for the pre and post values. (18)

study were linked to the prepubertal age group, as they adapt well to learn complex skills. Sehgal S et al. emphasised the need for basic skill development through movement stimulus for athletic growth [15]. As hypothesized, both training methods improved balance. Motor learning develops as children's nervous and musculoskeletal systems mature and is relied on multiple sensorimotor systems.

[Table/Fig-6]: Participant performing mSEBT in anterior, posteromedial and posterolateral direction on the left lower extremity

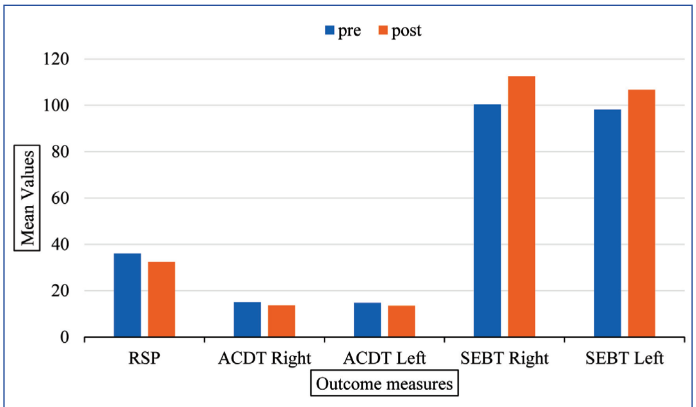
[Table/Fig-7]: Participant performing arrowhead change of direction speed test

Variables	Group A: Low Task Difficulty Balance	Group B: High Task Difficulty Balance
Age (years)	12.26±1.55	12.20±1.73
Height (cm)	153.83±10.31	146.63±7.28
Weight (kg)	50.53±5.89	48.50±9.87
BMI (kg/m²)	21.49±2.84	22.47±4.03
Gender (Male/Female)	14 (46.67%)/16 (53.33%)	15 (50%)/15 (50%)
Age Range (years)	10-15	10-15

[Table/Fig-9]: Demographic Data of Participants

Outcome Measures	Pre-Treatment Mean±SD	Post-Treatment Mean±SD	p-Value
Roller Skating Performance (RSD)(In seconds)	36.01±0.82	32.41±1.26	<0.001
Arrowhead Change in direction Speed test (Right side) (ACDT) (In seconds)	14.98±0.59	13.63±0.78	<0.001
Arrowhead Change in direction Speed test (Left side) (ACDT) (In seconds)	14.75±0.58	13.49±0.80	<0.001
Modified Star Excursion Balance Test (SEBT)(Right) (In cms)	100.40±12.32	112.55±13.62	<0.001
Modified Star Excursion Balance Test (SEBT)(Left) (In cms)	98.13±10.21	106.76±11.24	<0.001

[Table/Fig-10]: intragroup comparison of outcome measures for Group A: Low level of task difficulty balance training



[Table/Fig-11]: Comparison of pre and post-treatment outcome measures in Group A: Low level task difficulty balance training.

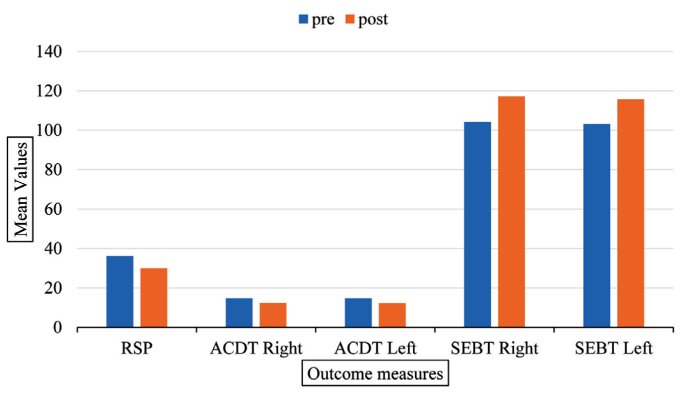
Outcome Measure	Pre-Treatment Mean±SD	Post-Treatment Mean±SD	p-Value
Roller Skating Performance (RSD)	36.12±1.45	29.97±1.08	<0.001
Arrowhead Change in direction Speed test (Right side) (ACDT)	14.69±0.54	12.37±0.47	<0.001
Arrowhead Change in direction Speed test (Left side) (ACDT)	14.69±0.33	12.28±0.37	<0.001
Modified Star Excursion Balance Test (SEBT)(Right)	104.22±8.93	117.14±9.92	<0.001
Modified Star Excursion Balance Test (SEBT)(Left)	103.20±9.70	115.72±10.70	<0.001

[Table/Fig-12]: Intra-Group Comparison of Outcome Measures for Group B: High level of task difficulty balance training.

Skating enhances strength and balance by requiring posture control and sensory-motor coordination [7,23].

Dynamic Postural Control

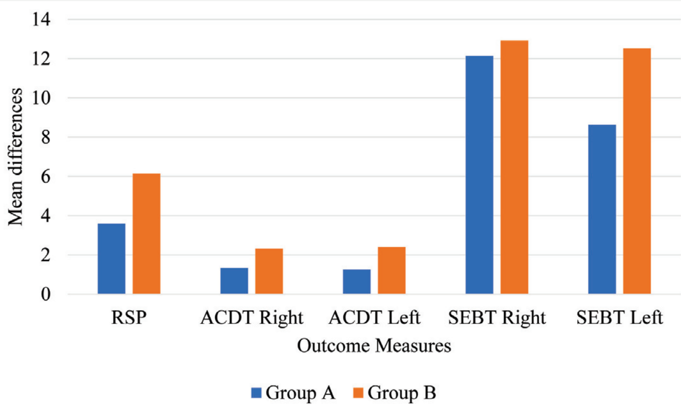
The findings of this study align with previous research examining the effects of balance training on balance performance metrics. Granacher U et al conducted research on high school students who underwent balance training for a duration of four weeks. It was determined that the balance performance showed notable enhancement in that group (i.e., decreased postural sway) [17]. Heleno et al carried out another study on soccer players, examining the impact of 5 weeks of balance training alongside their regular soccer training. The control group was not given the balance training. Consequently, it determined that the experimental group, which received balance training in addition to the standard soccer training, showed considerable improvements. The balance performance (greater reach distance) was enhanced in the experimental group compared to the control group. The findings of this study and the existing literature indicate that balance training is an effective approach to enhance various measures of balance performance in young athletes. [24-26] Our findings showed moderate improvements in reach distance with high-task difficulty balance training compared to low-task difficulty training. These results align with the study proposed by Gebel A et al. found that postural sway increased with task difficulty, enhancing neuromuscular activity and muscle activation [12]. High-difficulty



[Table/Fig-13]: Comparison of pre and post-treatment outcome measures in Group B: High level task difficulty balance training.

Outcome Measure	Group A: Low task difficulty balance training Mean difference±SD	Group B: High task difficulty balance training Mean difference±SD	p-Value
Roller Skating Performance (RSD)	3.60±0.88	6.14±1.27	<0.001
Arrowhead Change in direction Speed test (Right side) (ACDT)	1.34±0.54	2.32±0.52	<0.001
Arrowhead Change in direction Speed test (Left side) (ACDT)	1.26±0.74	2.40±0.40	<0.001
Modified Star Excursion Balance Test (SEBT)(Right)	12.14±1.71	12.92±1.60	>0.001
Modified Star Excursion Balance Test (SEBT)(Left)	8.63±1.73	12.52±1.73	<0.001

[Table/Fig-14]: Inter-Group Comparison of Outcome Measures for Group A and Group B



[Table/Fig-15]: Comparison of all outcome measures in Group A and Group B.

balance tasks promote greater sensory integration and postural control adaptation. Gebel A et al. observed increased cortical activity with rising task difficulty, suggesting enhanced adaptive abilities and performance benefits from high-task difficulty training [27]. This study confirms the effectiveness of task difficulty balance training in improving lower limb stability and performance, with significant mSEBT score improvements in both legs. Within-group analysis showed strong gains (p=0.0001), while between-group analysis revealed significance for the left leg (p=0.0001) but not the right (p=0.075), likely due to leg dominance. The non-dominant left leg showed greater neuromuscular adaptation. The intervention was safe and provides insights for future training to address leg dominance and enhance performance.

Speed and Agility

Speed, agility, and performance depend on neuromuscular specificity, coordination, stability, strength, and biomechanics. Tracy L. Hillis et al. found speed improves most during pre- and post-puberty, with neural activation strengthening muscles. Training should focus on neural adaptations, not just speed [3,25]. Balance ability has been found to correlate with key performance measures in certain sports. While the link between balance ability and injury risk is well established, its direct influence on athletic performance is more nuanced. Research suggests that balance training enhances performance by improving neuromuscular control, increasing rate of force development (RFD), and refining postural stability. [28] Increased co-contraction of agonist-antagonist muscles, due to suppressed stretch reflexes, may enhance joint stiffness and stability, supporting better balance. Activities like throwing and catching while walking on a balance beam likely improved reaction time by demanding quick responses to directional changes, as there appeared to be a greater effect in the high task difficulty balance training group compared to the low task difficulty balance training group [29]. Although both groups showed significant speed improvements, the high task difficulty group demonstrated greater gains based on mean differences.

Roller Skating Performance

Roller skating consists of 4 stages: right push, right back, left push, and left back. In all 4 phases of the roller-skating linear gait cycle, the explosive power of lower limb muscles, including hip extensors, abductors, rotators, quadriceps, hamstrings, and calf muscles, is crucial. This strength has been cultivated through balanced training of task difficulty, which improved the muscle activity of all muscles crucial for a sport demanding speed, agility, and quickness such as roller skating. The current study results showed significant improvements in both the groups for the skating performance (p=0.0001) but the high task difficulty balance training exhibited greater improvements than the low task training based on the mean differences. Complex balance tasks drive neuromuscular and cognitive adaptations that enhance skating performance by demanding greater use of visual, vestibular, and proprioceptive inputs, thereby improving multisensory integration and postural control. Progressively challenging exercises stimulate diverse motor pathways, promoting coordination, joint stability, and efficient movement during high-speed skating and turns. Training under progressively difficult conditions also enhances postural stability, ensuring skaters can maintain balance during intricate routines, jumps, and turns, particularly in artistic roller skating and speed skating events. [27,30]. While some studies suggest that low difficulty tasks may be more suitable for beginners, the current findings support the use of progressively challenging balance exercises to achieve superior neuromuscular adaptations and enhancing athletic performance [27].

By progressively increasing the complexity of balance tasks, athletes can improve their postural stability, proprioception, motor coordination, and cognitive focus. These adaptations not only contribute to better movement efficiency but also enhance sport-specific skills such as agility, reaction time, and strength transfer. Additionally, the integration of task difficulty balance training into athletic conditioning can serve as an effective injury prevention strategy, equipping athletes to handle unpredictable movements and maintain control under pressure. Overall, task difficulty balance training is an essential component of a comprehensive training regimen, helping athletes optimize their performance and minimize the risk of injury.

Limitation(s)

One limitation of this study was the lack of longitudinal assessment to determine the long-term retention of improvements and their effectiveness in reducing injury risks. Additionally, while the study focused on balance training, it does not explore the potential benefits of integrating these exercises with other athletic programs such as strength, endurance, or cognitive training, which could enhance overall performance. Another limitation was the absence of a direct comparison between different balance training approaches, particularly in terms of task difficulty, and how they compare to traditional or innovative training techniques. Future research should address these gaps to provide a more comprehensive understanding of balance training in roller skating biomechanics.

CONCLUSION(S)

The present study compared low and high task difficulty balance training on dynamic postural control, speed, and performance in young roller-skaters. Both protocols led to significant improvements across various metrics, with high task difficulty training showing superior gains. The findings support the alternate hypothesis, highlighting a difference in training effects. It was determined that Low Task Difficulty Balance training is beneficial, especially for those beginning at a lower skill or fitness level, while High Task Difficulty Balance training seems more effective in enhancing performance improvements, particularly for individuals who can manage greater challenges. Both methods are effective and safe, making them valuable for enhancing performance and reducing injury risk.

Acknowledgements

I sincerely thank all who contributed to the completion of this research. My deepest gratitude goes to my advisor for their invaluable guidance and support. I also appreciate the faculty and mentors for their constructive feedback and shared knowledge, which greatly enriched this work. Special thanks to my peers and colleagues for their helpful discussions and encouragement throughout the process. I am especially grateful to the participants, whose involvement was essential. Lastly, heartfelt thanks to my family and friends for their constant support and belief in me. This research was made possible by the collective efforts of everyone involved.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Apr 01, 2025
- Manual Googling: Oct 21, 2025
- iThenticate Software: Oct 23, 2025 (7%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: Mar 16, 2025
Date of Peer Review: Jul 03, 2025
Date of Acceptance: Oct 25, 2025
Date of Publishing: Feb 01, 2026