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Preventive Training Program Feedback Complexity, Movement Control, and Performance in Youth Athletes

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Context: Preventive training programs (PTPs) reduce injury risk by improving movement control. Corrective feedback is important; however, many cues at once may be too complicated for athletes.

Objective: To compare movement control and long-jump (LJ) changes in youth athletes participating in a season-long PTP, with simplified feedback, traditional feedback, or a warmup of the coaches' choosing.

Design: Cluster-randomized controlled trial.

Setting: Soccer fields.

Patients or Other Participants: A total of 420 athletes (simplified feedback = 173, traditional feedback = 118, and control = 129; age = 11 ± 3 years).

Intervention(s): Teams were randomized into the simplified PTP, traditional PTP, or control group. Simplified and traditional PTPs lasted 10 to 12 minutes and used the same exercises. The simplified PTP provided only sagittal-plane feedback (eg, "get low"), and the traditional PTP provided feedback targeting all motion planes (eg, "don't let your knees cave inward"). Research assistants administered the PTP warmups 2 to 3 times/week for the season. Control team coaches chose and ran their own warmup strategies.

Main Outcome Measure(s): Participants completed 4 sessions (preseason [PRE], postseason [POST] at approximately 8 weeks after PRE, retention 1 [R1] at 6 weeks postseason, and retention 2 [R2] at 12 weeks postseason). They performed 3 trials of a jump-landing task, which was evaluated using the Landing Error Scoring System (LESS) and 2 recorded standing LJ trials at each test session. A time series panel was used to evaluate group differences across time points for the LESS and LJ.

Results: Change score analyses revealed improvements in the LESS score from PRE to POST for all groups. Improvements from PRE were retained at R1 and R2 for the intervention groups (simplified and traditional). The traditional group demonstrated better LJ performance at POST ($P < .001$) and R1 ($P = .049$) than the simplified or control group.

Conclusions: Simplified cues were as effective as traditional cues in improving LESS scores from PRE to POST season. Participating in PTPs, regardless of their complexity, likely provides movement benefits.

Key Words: injury-prevention program, pediatric, adolescent, soccer, motor control

Key Points

- Simplified cues during preventive training program (PTP) implementation were as effective as traditional PTPs for improving movement quality in youth soccer athletes over a single season. Therefore, if the main goal of the PTP is improvement of movement quality in youth athletes, a simplified cueing or feedback strategy can be used.
- Traditional PTPs, focused on triplanar feedback and cueing, were the most efficient in improving long-jump performance and demonstrated the most sustained benefits across time. Teams and coaches wishing to also capitalize on the performance-enhancement benefits of PTPs should continue to focus on traditional cueing.
- The PTPs used in this study were overseen by several researchers, and thus, future investigators should evaluate whether our results can be replicated when the program is implemented autonomously by the coaching staff.

Evidence-based preventive training programs (PTPs) used as warmups are cost-effective strategies to reduce injury risk[1,2] and injury rates.[3–6] However, the effectiveness of PTPs for injury reduction is directly related to program compliance and exercise fidelity.[7,8] Despite a body of research indicating the benefits of PTPs, coaches do not commonly use these programs.[9] Coach "buy-in" is an important step to increase program compliance and adherence.[7,9] Two ways to potentially increase coach buy-in are to simplify programs for easier implementation and to highlight any athletic performance benefits related to PTP efficacy.[9,10]

Youths and adolescents are targeted for PTP implementation to address biomechanical risk factors for injury, such as movement control during sport-specific tasks, before and throughout physical maturation.[11] A key element of effective PTPs is the incorporation of feedback cues to ensure appropriate movement control. Too many cues delivered in 1 session or using cues that address a variety of motions may be (1) overly complicated, (2) counterproductive to skill acquisition for the athletes,[12] and (3)

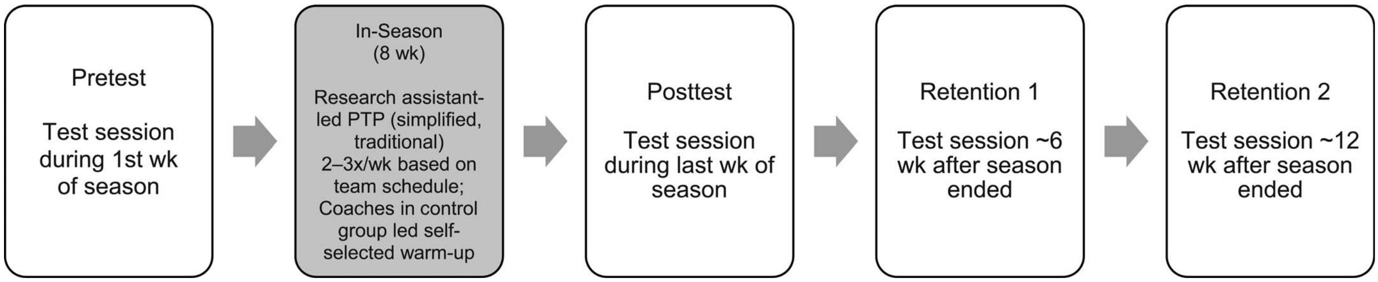

Figure 1. Flowchart of test sessions. Abbreviation: PTP, preventive training program.

perceived as too challenging to learn and be implemented by coaches. Implementation of PTPs may benefit from simplified, direct cues that focus on a crucial set of movements; however, whether simplified cues are as effective in reducing injury risk as the traditional use of feedback cues is unknown.

In addition to injury reduction, PTPs can enhance sport performance—specifically, strength and power metrics as well as functional performance are linked to consistent PTP implementation over time.[13–17] Coaches may be more likely to adopt and implement PTPs as part of their team warmup if benefits related to performance exist; yet whether a simplified PTP would yield similar performance gains to a traditional program is unknown.

Although robust evidence on the injury reduction and performance benefits of PTPs exists, the protective effects of PTPs may be transient.[18] The effects of PTPs must be assessed over time to determine if a single sport season is sufficient or if subsequent exposure is necessary to maximize the protective and performance effects.

Therefore, the first purpose of our study was to evaluate changes in movement control and long-jump (LJ) performance in youth athletes participating in a season-long PTP with simplified feedback cues, traditional feedback cues, or a warmup of the coaches' choosing. We hypothesized that simplified cues would result in improved movement control compared with traditional cues and that the simplified cues would be equally effective for improving LJ performance compared with traditional cues. The second purpose was to evaluate the retention of any improvements resulting from PTP implementation during 1 season. We further hypothesized that movement control and LJ performance improvements would be maintained at the first retention time point but would taper by the second retention time point.

METHODS

Research Design

Youth soccer teams between the under-8 and under-14 age groups from 4 local soccer organizations were invited to participate in this study. We used a subgroup analysis of a cluster-randomized controlled trial combined with a prospective time-series panel study design to measure changes from the intervention (trial) and retention (panel) in movement control and LJ performance.[19] Movement control and LJ performance were assessed in a convenience sample of *participants*, defined as athletes who were present and able to engage in physical activity on the day of testing at each of the 4 time points: before (PRE) and after (POST) the 8-week intervention period and approximately 6 weeks (R1) and 12 weeks postseason (R2; Figure 1). Postseason testing time points occurred over several days and times at the time points (R1 and R2) and by organization based on participant and team availability. Thus, the postseason testing sessions (R1 and R2) may have occurred at roughly 6 and 12 weeks. The university's institutional review board approved this study before league recruitment.

Participants

A total of 28 soccer teams, consisting of both male and female athletes, agreed to participate in the study and be randomized into 1 of the 3 groups. All youth athletes on each team were recruited to participate in the study during team informational meetings. Players and parents or legal guardians read and completed assent and consent forms, respectively, before data collection. All participants were free of any injury or illness that prohibited soccer activity at the times of testing. All athletes on every team completed their team's assigned warmup intervention, but only those who consented to participate in the study were tested. Attendance was not taken at each warmup implementation session, so individual athlete-exposures and program dosages were not recorded. At an organizational level, all teams and athletes had the opportunity to complete the intervention for 8 weeks.

Implementation of PTPs

The teams were stratified by age and sex and then randomized into 1 of 3 intervention arms: the PTP with simplified feedback cues (primarily in the sagittal plane; 10 teams), the PTP with traditional feedback cues in all planes of motion (9 teams), or the control (9 teams). Teams assigned to the simplified or traditional program were assigned a research assistant who implemented the 10- to 12-minute PTP (Table 1) before every practice (at least 2 to 3 times per week depending on the team's schedule) for the 8-week intervention. Research assistants were assigned to the simplified and traditional programs to ensure consistency due to the novelty of the feedback strategies.

Research assistants completed training on PTP implementation led by an investigator (L.J.D.) in a single, in-person, 2-hour session. Training included how to physically perform the program exercises as well as how to implement the program and provide appropriate movement cues based on the team's assigned group (simplified or traditional). Research assistants assigned to each team administered the PTP warmup and provided oral feedback and technique instruction to ensure program fidelity. No crossover

Table 1. **Preventive Training Programs**

Exercise	Description	Cues for Simplified Program	Cues for Traditional Program
Walking butt kick	Pull heel of 1 leg to buttock. Feel stretch on front of thigh. Balance on other leg with knee slightly bent. Hold for 3 s.	Keep balance leg slightly bent.	Keep balance leg slightly bent; point toes straight ahead.
Knee walk	Hands on hips. Lunge forward with 1 leg, lowering opposite knee to ground. Lean back to feel stretch in front of thigh on back leg.	Controlled, slow motion.	Toes straight ahead; knee stacked over toe; controlled, slow motions.
Elephant walk	Straighten 1 leg in front with heel on the ground. Bend at the hips, swinging arms down thigh to lower leg. Swing arms up as you step forward.	Keep knee straight.	Toes straight ahead, knee stacked over toe; keep back flat.
Frankenstein	Step forward and balance on 1 leg. Raise your other leg straight ahead while keeping your knee straight.	Raise leg to lower height if needed to keep knee straight.	Raise leg to lower height if needed to keep knee straight; toes pointed straight ahead.
Forward hop to balance	Hands on hips, standing on 1 leg. Hop forward. Land softly on opposite leg with trunk, hip, and knee flexed. Hold for 5 s.	Land as softly as possible; bend your knees, hips, and trunk.	Land as softly as possible; bend your knees, hips, and trunk.
Ball around the world	Hands on hips, balancing on 1 leg. Toe-tap the ball from 12:00 to 6:00 clockwise or counterclockwise.	Keep stance knee bent.	Keep stance knee bent.
Double-legged squat	Hands on hips. Feet shoulder-width apart. Squat down like sitting in a chair.	Sit back.	Toes straight ahead, knees over toes; sit back.
Frog jump	Squat down. Jump for maximum height. Land softly in squat position.	Sit back; land softly; get low.	Toes straight ahead, knees over toes; land softly; sit back.
Plank	Push-up position with elbows on the ground. Keep upper and lower body as straight as possible.	Stay "straight as an arrow"; draw your belly button toward your spine while breathing.	Stay "straight as an arrow"; draw your belly button toward your spine while breathing.
Hip bridge	Lie with back on ground, knees bent, and feet flat on the ground. Slowly lift hips off the ground and hold. Hands on hips and elbows on the ground. Progress to arms across chest. Lift 1 s, hold 10 s, lower 2–3 s.	Keep your thighs, hips, and trunk in a straight line; draw your belly button toward your spine while breathing.	Keep your thighs, hips, and trunk in a straight line; draw your belly button toward your spine while breathing; toes straight ahead.
Side hop	Hands on hips. Bounce side to side over line on 2 feet. Progress to single-leg hops at week 3.	Stay on balls of your feet; land softly.	Stay on balls of your feet; land softly; toes straight ahead; knees over toes.
Forward skipping	Skip forward using arms for momentum. Start skipping for proper technique, then progress to speed.	Land softly.	Toes straight ahead, knees over toes; land softly.
T-shuffle	Jog 10 m, plant, cut, and side shuffle 10 m. Plant, cut, and shuffle back 10 m. Sprint to end cone.	Get low! Sit back.	Sit back; stay on balls of your feet.

between research assistants and treatment arms occurred. Teams assigned to the control group performed their normal warmup as determined by their coaches. Control teams were supervised once a week by a research assistant who recorded the warmup components to account for any similarities between the control warmup and the simplified or traditional PTP. Teams were never observed completing any standardized exercises as a team warmup other than warmup cardiovascular laps around the field. The research assistant did not implement the warmups for the teams assigned to the control arm.

Simplified Versus Traditional PTPs

The PTP was modified from previous anterior cruciate ligament (ACL) injury-prevention programs that have been successful for youth populations in decreasing injury risk[2,20] and was designed to be a dynamic warmup lasting 10 to 12 minutes (Table 1). The simplified and traditional PTPs consisted of identical flexibility, balance, strengthening, agility, and plyometric exercises and differed only with respect to the oral cues provided by the research assistant during the warmup. For the simplified PTP, research assistants corrected and cued only the movement technique in the sagittal plane (eg, "get low," "bend your knees!"). The traditional-feedback PTP research assistants provided corrections and cues for all planes of motion (eg, "point your toes straight ahead," "don't let your knees cave inward").

Movement Control Assessment

Participants completed 3 trials of a standardized jump-landing task during each test session. During the task, participants jumped forward from a 30-cm-high box at a distance half their height and immediately rebounded straight in the air for maximum vertical height. Movement control during the jump-landing task was evaluated using the Landing Error Scoring System (LESS). The LESS is a valid and reliable clinical movement assessment that can identify youth athletes at low risk for sustaining an ACL injury.[21] All trials were video recorded from the frontal and

Table 2. Participant Demographics Extended on Next Page

Characteristic	PRE (1st Week of Season) Simplified PTP (n = 173)	PRE Traditional PTP (n = 118)	PRE Control PTP (n = 129)	POST (Last 1–2 Weeks of Season) Simplified PTP (n = 173)	POST Traditional PTP (n = 118)	POST Control PTP (n = 129)
Age, median (range), y	11 (8–13)	11 (8–14)	11 (8–13)	11 (8–13)	11 (8–14)	11 (8–13)
Sex, No. (%)						
Male	73 (42)	64 (54)	57 (44)	48 (45)	47 (54)	43 (47)
Female	100 (58)	54 (46)	72 (56)	58 (55)	40 (46)	48 (53)
Height, mean ± SD, cm	149.51 ± 13.02	151.45 ± 11.38	150.15 ± 9.78	151.28 ± 12.05	153.28 ± 11.51	151.23 ± 12.88
Mass, mean ± SD, kg	42.01 ± 10.75	42.64 ± 11.37	41.45 ± 9.74	42.00 ± 10.16	43.28 ± 11.71	41.90 ± 10.06

Abbreviation: PTP, preventive training program.

sagittal planes. A single reliable rater graded all trials at a later time point. The rater was trained by an expert and blinded to the group assignment of the participants. The total scores from each of the 3 trials were averaged for 1 composite LESS score at each time point. The LESS score is a summation of movement errors displayed, in which a higher score indicates more movement errors and a lower score indicates fewer movement errors during the jump-landing task.

Long Jump

Standing LJ performance is considered a measurement of power.[22] Participants began the LJ by standing behind a marked line. They had to remain standing but could move into a self-determined semi-squat position to jump horizontally as far as possible. Each person performed 1 practice and 2 recorded trials. Trials were repeated if the individual fell or slipped during the trial. Distance jumped was recorded to the nearest centimeter from the starting line to the closest body part on the ground manually using a standard measuring tape. The 2 trials were averaged for 1 composite score at each time point.

Statistical Analyses

A repeated-measures design in which the same participants are tracked longitudinally over time is not ideal in large youth sport or educational settings due to both the reality of multiple testing time points in a youth population and the concerns associated with the ability of such a design to account for heterogeneous variability.[23–25] Instead, we used a time-series panel design, in which the groups were compared using a cross-sectional approach at each assessment point.[19,25] The panel design is logistically simpler to implement with large samples of children, eliminates bias from loss to follow-up, maximizes power, and reduces the potential for a learning effect. This design is statistically efficient when within-subject correlations are low and has been used in studies conducted in educational and military settings.[19]

Potential differences in age and sex among groups at PRE were evaluated using a 1-way analysis of variance and χ^2 test of association, respectively. We calculated change scores for the LESS and LJ variables for each group (simplified, traditional, and control) for each time point compared with baseline (POST-PRE, R1-PRE, and R2-PRE). This baseline comparison among groups ensured that any group effects observed during the follow-up time points were not due to preexisting group differences.

For the panel design, data from all participants who completed testing at each time point were included in each individual time-point analysis. We performed separate univariate analyses of variance with a Bonferroni correction to determine whether group differences (simplified, traditional, and control) existed for LESS scores and LJ performance at each of the 3 follow-up time points (POST, R1, and R2). If a significant group effect was observed, we conducted post hoc pairwise comparisons by evaluating 95% CIs. All data were analyzed using SPSS (version 21.0; IBM Corp) with a prior α level of .05.

RESULTS

All 28 teams completed the interventions as assigned. A total of 420 athletes (simplified group = 173, traditional group = 118, and control group = 129) volunteered to participate in the test sessions. All groups were similar at baseline for sex, age, height, and mass (P values $>$ .05; Table 2).

Landing Error Scoring System

No group differences were present at POST ($P = .07$), R1 ($P = .557$), or R2 ($P = .483$). The change-score analysis revealed improvements in the LESS score at POST for all 3 groups compared with PRE. Improvements from PRE were also present at R1 and R2 for both intervention groups (simplified and traditional; Table 3; Figure 2).

Long Jump

The traditional group jumped further on the LJ than both the control and simplified groups at POST ($P < .001$) and further than the control group at R1 ($P = .049$; Table 3; Figure 3). The traditional group demonstrated improved LJ performance from PRE to POST. Long-jump performance decreased for the simplified and control groups at R1 compared with PRE and for all 3 groups at R2 compared with PRE.

DISCUSSION

This study was a comparative efficacy trial to evaluate whether a simplified approach to PTPs elicited greater immediate and retained improvements in movement control and LJ performance in youth athletes. The population was youth soccer athletes between the ages of 10 and 12 years. These ages reflect a critical window of opportunity for promoting appropriate motor development.[26] In addition, establishing PTPs as a norm in sport participation at a

Table 2. Extended From Previous Page

R1 (6 Weeks After Season End)			R2 (12 Weeks After Season End)		
Simplified PTP (n = 173)	Traditional PTP (n = 118)	Control PTP (n = 129)	Simplified PTP (n = 173)	Traditional PTP (n = 118)	Control PTP (n = 129)
11 (8–13)	11 (8–14)	11 (8–13)	11 (8–13)	11 (8–14)	11 (8–13)
36 (42)	30 (59)	23 (35)	45 (49)	38 (58)	29 (44)
49 (58)	21 (41)	42 (65)	46 (51)	27 (42)	37 (56)
154.55 ± 11.78	151.19 ± 10.96	152.64 ± 10.43	152.84 ± 10.17	150.57 ± 9.97	152.40 ± 10.00
44.08 ± 10.46	39.76 ± 10.22	41.96 ± 10.38	45.07 ± 11.77	42.52 ± 11.42	42.79 ± 11.03

young age may greatly promote long-term acceptance of these programs when injury risk increases in the later ages of adolescence. Our results showed that PTPs, delivered as either a traditional or simplified approach, were effective in improving movement control, as measured by the LESS, with effects persisting as long as 12 weeks after completion of the program. Although these improvements were not different than those from a warmup of the coaches' choosing, PTP use at this young age may be critical for building buy-in and acceptance of these types of warmup strategies given that the benefits of PTPs in adolescence for reducing injury risk are clearly established.[27–29]

Coaches represent the best option for consistent, long-term use of PTPs, particularly at the youth level; however, high program complexity can be a barrier to implementation,[30] and coaches have reported that knowing how to give adequate feedback to athletes on injury-prevention techniques is a challenge.[31] Motor learning can be affected by the type of feedback provided, which can differ based on the focus of attention (eg, internal or external) and complexity.[32] Feedback that is too complex may be challenging for children and counterproductive to learning.[12] Our findings indicated that a PTP implemented with simplified feedback cues to athletes was as successful as a PTP with a wide range of feedback cues in eliciting movement-control improvements, as measured by the LESS. Youth sport coaches are capable of effectively implementing PTPs after a workshop,[33,34] and authors of future studies should evaluate the training of coaches to use a streamlined set of feedback cues, which would simplify both the coaches' training as well as daily program implementation for the athletes.

Although the PTP programs for movement control produced similar outcomes, the traditional program elicited greater changes in LJ performance than the simplified program and the control group. The LJ is a measure of power and muscular fitness.[22] Thus, to achieve performance benefits, training programs must incorporate the progressive loading needed to achieve strength gains.[35] As performance gains declined more quickly for the simplified and control groups than the traditional group, it is likely that the athletes in these groups did not incur enough overloading to cause gains in power performance. Athletes in the traditional program saw declines but over a longer period, indicating that this program elicited more sustainable changes in performance than the other programs. Past researchers[36,37] demonstrated that traditional injury-prevention programs result in improved performance measures,

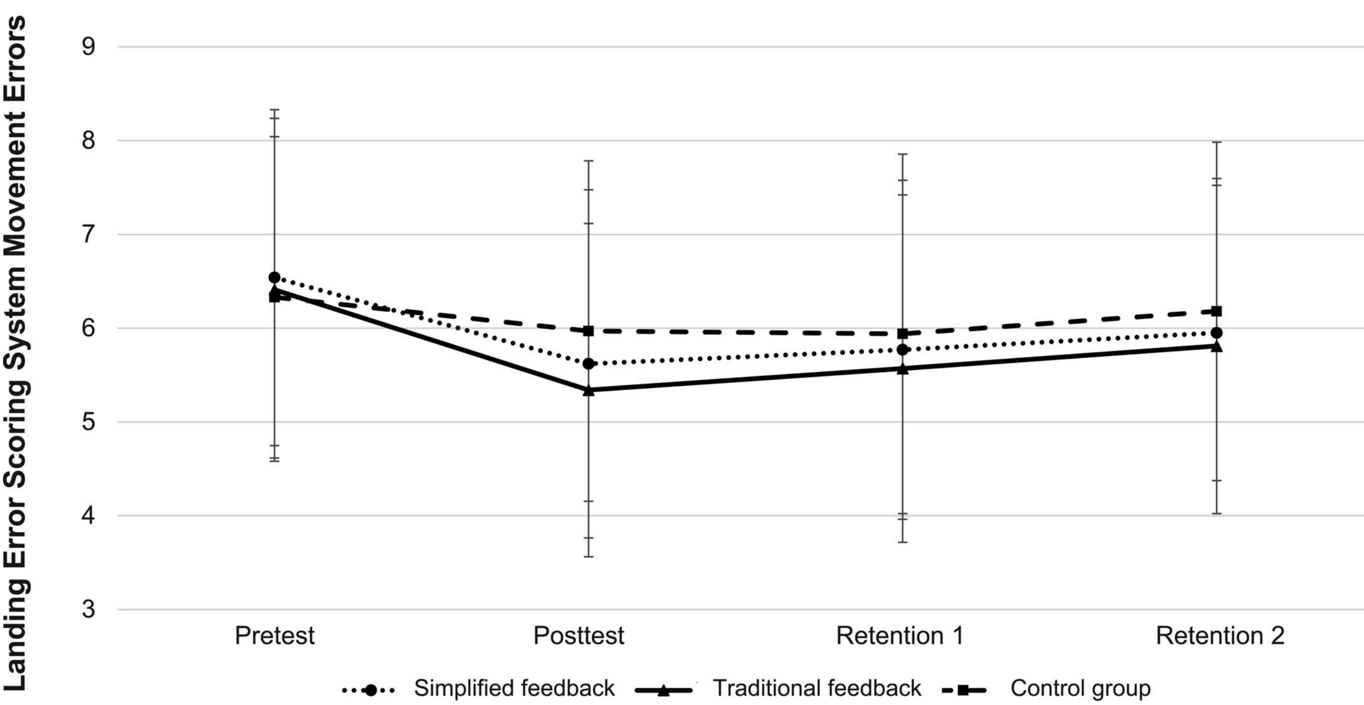

Figure 2. Landing Error Scoring System scores (No. of errors) over time by the warmup group (mean ± SD).

Table 3. Change Scores for the Simplified, Traditional, and Control Warmup Groups,[a] Mean ± SD (95% CI)

	Landing Error Scoring System Score, No. of Errors[b]			Long Jump, cm[c]		
	Simplified	Traditional	Control	Simplified	Traditional	Control
POST–PRE	−0.93 ± 2.19[d] (−1.41, −0.45)	−0.86 ± 1.74[d] (−1.26, −0.47)	−0.47 ± 1.69[d] (−0.87, −0.08)	−0.67 ± 4.68 (−1.62, 0.27)	2.98 ± 6.35[d] (1.60, 4.36)	−0.49 ± 5.42 (−1.64, 0.65)
R1–PRE	−0.85 ± 2.05[d] (−1.33, −0.38)	−1.07 ± 2.20[d] (−1.74, −0.40)	−0.39 ± 1.91 (−0.89, 0.11)	−4.01 ± 7.48[d] (−5.69, −2.33)	−2.37 ± 8.32 (−4.73, 0.00)	−5.82 ± 6.79[d] (−7.50, −4.14)
R2–PRE	−0.59 ± 1.84[d] (−1.03, −0.15)	−0.64 ± 1.72[d] (−1.13, −0.15)	−0.18 ± 1.65 (−0.64, 0.27)	−4.96 ± 6.03[d] (−6.26, −3.66)	−4.30 ± 7.63[d] (−6.21, −2.40)	−5.16 ± 5.79[d] (−6.58, −3.74)

Abbreviations: POST, last 1–2 weeks of the season; PRE, during the first week of the season; PTP, preventive training program; R1, 6 weeks after the end of the season; R2, ~12 weeks after the end of the season.

[a] The simplified group received feedback cues in the sagittal plane. The traditional group received feedback cues in all planes of motion. The control group performed warmups as determined by the team's coach.

[b] A negative change indicates better performance (ie, fewer movement errors).

[c] A positive change indicates better performance (longer distance).

[d] Significant change as determined by the 95% CI of the change value.

including strength, power, coordination, posture, balance, and agility. The traditional and simplified programs we used consisted of similar types of exercises; the former were more challenging, with demands across all planes of motion. These challenges appear to be important, even with a short dynamic warmup exercise program, for the neuromuscular improvements that produce power improvements in youth athletes. Only the traditional PTP group improved from PRE to POST and then steadily declined at R1 and R2. Earlier authors[38,39] evaluated the effect of PTPs on injury risk or sport performance from preseason to postseason. We offer additional evidence that implementation strategies need to include maintenance plans beyond a single sport season to maintain performance benefits. Further, coaches may be more interested in performance improvements than injury-prevention benefits.[40] Therefore, to generate initial buy-in for long-term implementation, it may be important to consider which program strategy facilitates greater performance changes.

We applied an innovative time-series panel design for sports medicine. This design involves a cross-sectional approach at each follow-up test point and includes all available participant data. This approach has been advocated for use in educational and military settings, as it reduces follow-up bias, maximizes power, and provides a snapshot of the population at each test point.[19] A classic approach in sports medicine for this type of study would be a repeated-measures design in which only the participants who completed all 4 test points would be included in the analyses. With this method, significant data (approximately 36% to 50%) would have been lost to attrition. Field studies of large samples of children are greatly needed in sports medicine to understand the true effects of various interventions. However, field testing carries scheduling challenges at the organization, team, and individual level, particularly in the context of volunteer coaches and young athletes who may have variable levels of attendance. Tracking individual athletes' program dosages and recording the specific duration between 2 testing time points are important considerations for understanding effectiveness. We encourage investigators to consider using a time-series panel approach in future studies of large samples of children.

To our knowledge, this is the first investigation to evaluate the effect of simplified cues during a PTP on movement control and sport performance. Given the novelty of the research question, we controlled program adoption, fidelity, and compliance by relying on trained research assistants to implement the program. A limitation of this work was that we did not track athlete-level attendance for each warmup session, so the individual dosages for each program are unknown. Further, multiple testing time points were possible. For each of the 4 time points, testing was conducted over multiple (1 to 4) days to provide ample opportunity for athletes to participate. For example, retention testing for 1 organization took place over 2 different days, which could have influenced the number of days between the last program exposure and testing of participants within the same warmup group. This should be considered in the context of our findings and the absence of large group differences. Even so, our results still demonstrated improvements across time, regardless of the slight deterioration from R1 to R2. This indicates that, at

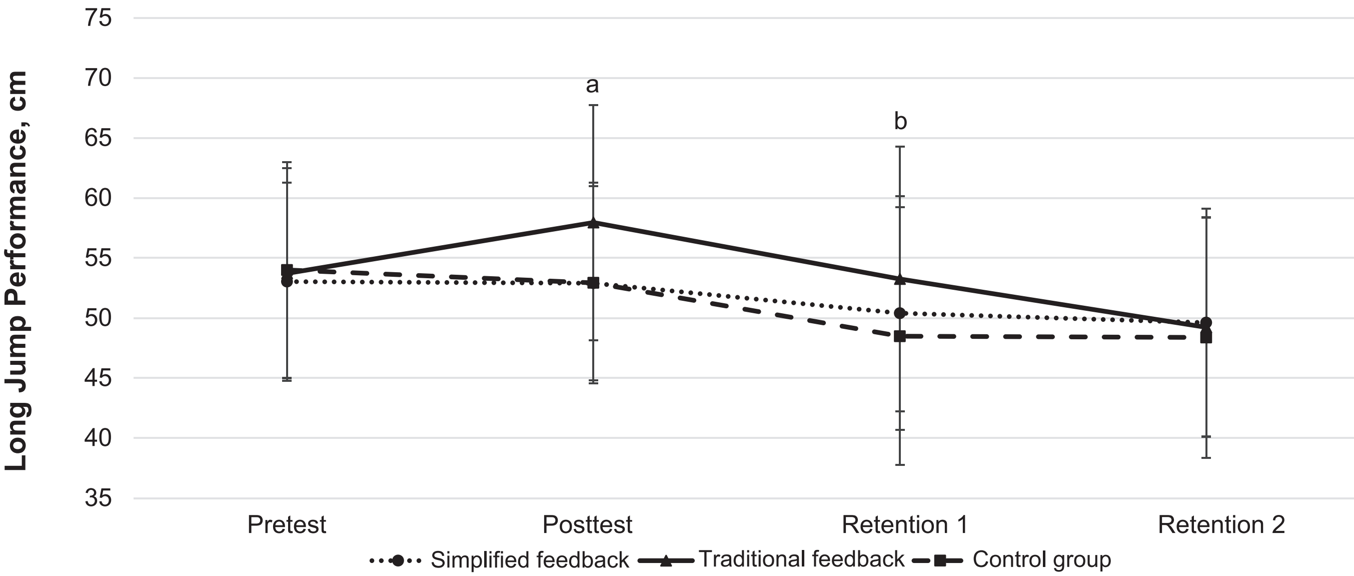

Figure 3. Long-jump performance (mean ± SD) over time by warmup group. [a] Traditional group compared with the simplified and control groups ($P = < .001$). [b] Traditional group compared with the control group ($P = .049$).

the simplest level, PTP programming at the team level improved movement control. Program maintenance is important, and future researchers must determine a threshold dosage for individual athletes to maximize long-term PTP effectiveness. Subsequent researchers can now evaluate the effectiveness of simplified movement cues on movement control and jump performance. In addition, although having 2 retention time points was a strength of the design necessary to measure true motor learning, participant attrition occurred at each time point, as follow-up communication with athletes was more challenging after the season ended. Future directions for this work should address mechanisms to reduce attrition between time points. Moreover, the PTPs were overseen by investigators, and thus, it will be important to identify whether these results can be replicated when the program is implemented by the end users (eg, coaching staff).

CONCLUSIONS

The delivery of PTPs using simplified sagittal-plane cueing strategies provided movement-quality improvements similar to those of a traditional PTP that supplied feedback in the frontal, sagittal, and transverse planes. These findings highlight the capability of simplified PTPs to directly influence movement control in younger athletes who may be overwhelmed by too many feedback cues. Authors of future studies should evaluate the effectiveness of such programs when they are delivered autonomously by coaches as well as the effects of other PTP adaptations in a real-world context.

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