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The Effects of Ankle Taping on Measures of Ground Reaction Forces and Jump Height During a Sport-Specific Vertical Jump in Youth Basketball Players

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ABSTRACT

International Journal of Exercise Science 16(6): 898-911, 2023. The purpose of this study was to investigate the effects of ankle taping using zinc oxide tape versus no tape to measure ground reaction forces (GRF) and vertical jump height during a sport-specific vertical jump test in youth basketball players. Participants were recruited through purposive sampling and completed a basketball specific vertical jump test with and without zinc oxide tape. Mean sway velocity, 95% ellipse area, and path length were measured using the AMTI© force platform and vertical jump height using a Vertec© device. A paired t-test with a significance level of $p < .05$ was used for analysis. 23 individuals participated (11 females, 12 males; aged M = 15.22 years; height M = 171.43 cm; mass M = 64.72 kg). There was a statistically significant decrease in jump height with tape (M = 57.33 cm) compared to without tape (M = 58.84 cm), 95% CI [2.74, 0.28], t (20) = -2.56, $p < .05$, d = .56; statistically significant decrease in 95% ellipse area with tape (M = 2.64 cm.cm) compared to without tape (M = 3.30 cm.cm), 95% CI [0.50, 0.02], t (22) = -2.26, $p < .05$, d = .47; statistically significant decrease in sway velocity with tape (M = 2.82 m/sec) compared to without tape (M = 4.08 m/sec), 95% CI [7.47, 0.27], t (22) = -2.22, $p < .05$, d = .46; and a statistically significant decrease in path length with tape (M = 120.93 cm) compared to without tape (M = 170.10 cm), 95% CI [37.37, 1.33], t (22) = -2.23, $p < .05$, d = .46, with a medium effect size for all variables. The application of taping the ankles resulted in increased ankle stability at landing, however, basketball jumping performance may be negatively affected as taping resulted in a decreased vertical jump height.

KEY WORDS: Inversion sprain, prophylactic taping, range of motion, postural sway, prevention, center of pressure

INTRODUCTION

Ankle injuries remain as one of the most predominant musculoskeletal injuries among the youth population (32). In basketball, 62.4% of injuries occur in the lower limbs, with the ankle being the most affected joint representing 70% of these injuries (25). Inversion sprains account for approximately 90% of all basketball-related ankle injuries (10, 28). Most ankle sprain injuries involve the lateral ligaments, specifically the anterior talofibular ligament, which is usually torn during plantarflexion and inversion movements that exceed the ankle's physiological range of motion (ROM; 12, 25). Basketball players can perform 40 or more jumps during a typical basketball game (12). Actions such as landing can place athletes in vulnerable positions that increase their injury risk (12). Landing has been reported as the most frequent sports movement associated with ankle sprains, with an occurrence rate of 45% following a jump (2).

These high injury rates emphasize the importance of preventative methods and treatments for reducing ankle sprains and instability (12, 26). Prophylactic interventions such as ankle taping can be used to prevent and minimize injury risk to basketball players by reducing the stress on the ankle stabilizers (13, 28). Prophylactic ankle taping has been shown to restrict excessive ankle inversion and eversion movements up to 41% of their ROM (28). Taping has also been theorized to increase the stimulation of cutaneous mechanoreceptors to enhance the proprioceptive input surrounding the ankle joint which can influence peroneal muscle activity and increase postural stability (31). Taping the ankle can also affect an individual's mental state during sport by enhancing perceptions of stability, confidence, and level of comfort (13).

Bracing and taping have been shown to decrease injury risk by 50-70% in those with a history of ankle sprains (8). Prophylactic ankle taping is a preferred method as it increases comfort and support while decreasing the interference on ankle function (20). Rigid sports tape is commonly used to support an unstable ankle by reducing the joint's ROM and restricting movements that predispose individuals to injury risk without influencing athletic performance (20). Many studies have concluded that prophylactic taping can prevent injury by reducing ankle inversion ROM to prolong the time needed to reach maximal ranges which allows the structures to properly counteract the movement (24, 28). Ankle taping has also been shown to improve postural control and stability during landing (13). Rigid sports tape, however, has also been shown to cause a significant decrease in vertical jump height performance in basketball (1).

Since landing in basketball has been reported as the most frequent sports movement that causes ankle sprains (28), ground reaction forces (GRFs) can be used to analyze landing movements. Ground reaction forces measure whole-body movements through the control and balance of the base of support provided by both feet (11). As an individual performs a landing task, the magnitude of GRF is affected, impacting the body's balance and ankle stability (29). Force platforms have been used in previous research to measure GRFs (11). The force platform measures three-dimensional forces (Fx, Fy, and Fz) and moments (Mx, My, and Mz) that provide the center of pressure (COP) coordinates which allow for postural movements to be calculated (22). Ground reaction forces can be used to measure the overall stability and balance of landing movements in basketball skills such as vertical jumping.

Basketball players must perform a high number of jumping movements through defensive and offensive maneuvers such as blocking, rebounding, stealing, and shooting (30). Thus, there is a need to further research sport-specific jump tests that mimic game-like situations as injuries rarely occur in static positions (11, 21). Vertical jumping is a complex movement that involves motor coordination and is considered an essential motor skill in basketball (16, 21). Rodríguez-Rosell et al. (21) concluded that a sport-specific three-step vertical jump approach proved to be a reliable test to assess vertical jumping ability in basketball players, however, this study did not consider the effects of taping. Little attention has been given to the effects of ankle taping in youth basketball players when completing a more dynamic basketball-specific vertical jump approach. Therefore, the purpose of this study was to examine the effects of ankle taping using zinc oxide tape versus no tape to measure GRFs and vertical jump height during a sport-specific vertical jump in youth basketball players. Based on the previous literature, it was hypothesized that with the application of tape to the ankles during a sport-specific vertical jump test, vertical jump height would decrease, and ankle stability would increase.

METHODS

Participants

A power analysis a priori was conducted using a sample size calculator with a confidence level set at 95% and margin of error at 5% and it was recommended that a sample size of 28 or more participants should be collected (Calculator.net, 2021). All efforts were made to try and recruit 28 participants to maintain this high level of power, however, only 23 individuals were recruited. Participant demographics are presented in Table 1. Participants were healthy male and female basketball players between the ages of 13-17 years who participated in basketball at the school or competitive level at least two days a week. Participants were free of any diagnosed lower extremity musculoskeletal injury or surgical ankle procedures in the past six months and were free of allergies to adhesive sports tape. All participants provided written informed consent prior to participation and the Lakehead University School of Kinesiology Undergraduate Research Ethics Committee approved the protocol used in this study. This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (19).

Table 1. Participant demographics.

Sex	11 Female, 12 Male
Age (years)	15.22 ± 1.20
Height (cm)	171.43 ± 14.31
Mass (kg)	64.72 ± 9.48

Protocol

Participants scheduled a one-time 40-minute testing session at Lakehead University.
Each participant completed a pre-screening Get Active Questionnaire (GAQ) to ensure he/she/they met all criteria to partake in the protocol (3). After completing the informed consent form and GAQ, the participant's gender, age (years), height (cm) using a measuring tape, and mass (kg) using a standard scale were recorded. The Vertec© device (Gill Athletics, Champaign, IL, USA) was then set to the appropriate standing reach height for each participant through having the participant standing shoulder width apart underneath the device with their dominant arm extended overhead. The Vertec© device was raised so that the lowest plastic vain was touching the top of the participants fingers.

Each participant performed a supervised standardized warm-up which consisted of approximately 5-10 min of full body stretching. A brief 2 min rest period was provided following the warm-up while the sport-specific vertical jump test was explained. The sport-specific vertical jump chosen was a three-step approach with a two-leg take-off to mimic jumping skills performed in basketball, such as rebounding and blocking. Each participant was given two practice trials to ensure that he/she/they understood the jump and could land on the force platform. This approach was performed in a starting position with the participant's lead foot behind the starting line, placed 3 m away from the Advanced Mechanical Technology Incorporated© (AMTI©) force platform (Advanced Mechanical Technology Inc., Watertown, MA, USA). A verbal signal "go" was given from the student researcher to start the approach.

The participant was asked to perform a fast three-step approach followed by a leap into a two-foot landing in front of the force platform. As the participant landed, they swung their arms backward in preparation for the jump. As they jumped as high as possible, the participant touched the Vertec© device at the highest plastic vane that he/she/they could reach and then landed on the AMTI© force platform with two feet simultaneously. The Vertec© device was set up beside the force platform to record vertical jump height before the participant landed. The participant performed three individual trials of the sport-specific vertical jump test with their basketball shoes on with no zinc oxide tape with a 1 min break in-between each trial. Data from all three trials were recorded with the AMTI© force platform and the Vertec© device. If the participant did not land properly on the force platform, then an additional trial was performed to ensure there were three trials recorded with useable data. The average vertical jump height, mean sway velocity, path length, and 95% ellipse area of all three trials were calculated. After the three trials were completed, the participant received an approximate 5 min rest period while the student researcher taped the participant's ankles using zinc oxide tape. Then the participant followed the same procedure to complete three more trials of the sport-specific vertical jump.

Taping Technique: A modified traditional taping technique was used to apply the zinc oxide tape that involved anchors, stirrups, figure-eight wraps, and heel locks (see Figure 1; 1, 15). The student researcher performed the ankle taping for each participant to ensure consistency. Pre-wrap was wrapped around the ankle to minimize the risk of skin irritation to the participant. Two brands of zinc oxide tape were used to complete the taping of the participant's ankles, 6.35 cm zinc oxide Mueller M-Tape© (Mueller Sports Medicine, Prairie du Sac, WI, USA) and 6.35 cm zinc oxide Johnson and Johnson Coach Athletic Tape© (Johnson & Johnson Inc., Markham, ON, Canada).

Figure 1. Modified traditional taping technique and steps that was used to tape each of the participants ankles.

AMTI© Force Platform: The AMTI© force platform was used to collect data on GRFs. The AMTI© force platform used was 50.8 cm by 45.7 cm. For the purpose of this study, mean sway velocity (m/sec), path length (cm), and 95% ellipse area (cm.cm) were measured. Mean sway velocity is the average change in the COP in the mediolateral and anteroposterior directions in force per second (6). Path length has been proven as a valid measure for balance conditions as it measures the distance travelled away from the COP over time (4, 9). The 95% ellipse area is a measure of the amount of movement from the COP where an ellipse is created which includes 95% of all data points collected (22; see Figure 2). Balance measures were collected and analyzed with the AMTI© force platform. The AMTI© force platform has been proven as a reliable way to measure GRFs during vertical jump tests (7). The AMTI© force platform was set up through the Netforce© software (Summit Medical and Scientific, Bookham, United Kingdom). The student researcher completed a hardware zero and then set the acquisition settings to a duration of 5 s and a frequency of 200 Hz.

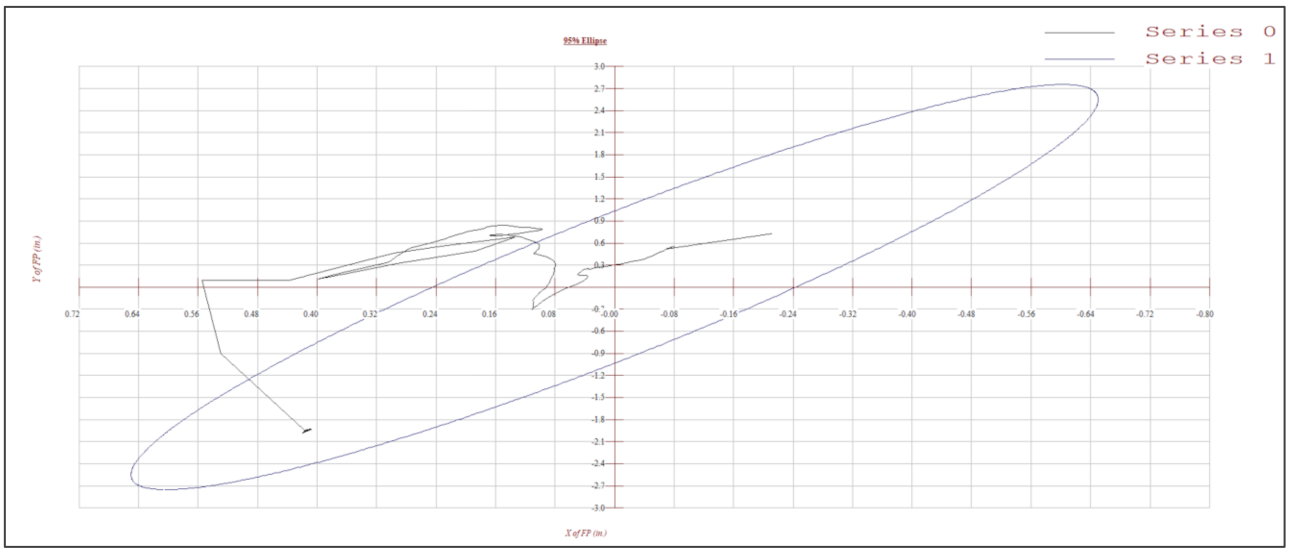

Figure 2. Visual example of a 95% ellipse area graph. Series 0 highlights the path of movement from the COP. Series 1 highlights the ellipse containing 95% of all data points collected.

Vertec© Device: For this study, a Vertec© device was used to collect vertical jump height data. The Vertec© device is a measurement tool designed with plastic swivel vanes arranged at 1.27 cm increments attached to a metal pole and is a well-established method for analyzing vertical jump height and performance (5, 18). The differences between the maximum vertical jump height and the fully extended standing reach height were calculated (14). For this study, if the participant jumped higher than the device, the device was moved up by 30 cm, and this number was then added to the measured jump height after each trial. If the Vertec© device could not be raised any higher due to the roof restrictions, then the device was raised as high as possible, the raised height was added to the jump height, and it was noted that the participant maxed out the device and roof height.

Statistical Analysis

The landing data was collected using the AMTI© force platform and was analyzed using the Bioanalysis© software (Summit Medical and Scientific, Bookham, United Kingdom). The vertical jump height data was collected using the Vertec© device and was analyzed through a spreadsheet. Force platform data and vertical jump height data were averaged for the three recorded trials with no tape and with tape. The trials where the participants did not land on the force platform properly were not included in the analysis. Following data analysis, data was transferred into Statistical Package for the Social Sciences© (SPSS©) version 27 (International Business Machines [IBM] Corporation, Armonk, NY, USA) for statistical analysis. Descriptive statistics were used to compare means and standard deviations of the participant's vertical jump height and GRFs. One independent variable [taping condition (with tape and without tape)] and four dependent variables [vertical jump height (cm), mean sway velocity (m/sec), path length (cm), and 95% ellipse area(cm.cm)] were examined. All analyses were performed with and without present outliers to determine their influence on the results and all data was checked for normality using the Shapiro-Wilk test. If data was not normally distributed, it was visually analyzed for violations. Following this, the data was analyzed using a paired samples t-test design to examine each dependent variable separately. The rejection criteria were set at alpha level $p < .05$.

RESULTS

The results of this study provide evidence that vertical jump height performance, mean sway velocity, path length, and 95% ellipse area were decreased when the sport-specific vertical jump test was completed with zinc oxide tape applied to the ankles. A summary of the descriptive statistics for all dependent variables during the sport-specific vertical jump test are presented in Table 2.

Table 2. Descriptive statistics for the sport-specific vertical jump test.

	No Tape			Tape		
Dependent Variable	Mean	SD	*n*	Mean	SD	*n*
Vertical Jump Height (cm)	58.84	15.97	21	57.33	14.85	21
Mean Sway Velocity (m/sec)	4.08	3.77	23	2.82	2.51	23
Path Length (cm)	170.10	157.20	23	120.93	104.85	23
95% Ellipse Area (cm.cm)	3.30	1.52	23	2.64	1.40	23

Note. cm = centimeters, m/sec = meters per second, cm = centimeters, cm.cm = centimeters x centimeters.

Missing Data: Due to the presence of outliers, usable data for vertical jump height measures was $n = 21$. Two outliers were detected for vertical jump height that were more than 1.5 box lengths from the edge of the box in a boxplot. Inspection of their values revealed them to be extreme, and they were removed from the analysis. All other variables remained at $n = 23$ and were not highly affected by outliers or any other errors that caused the missing data.

Vertical Jump Height: There was a statistically significant mean decrease in jump height of 1.51 cm with tape ($M = 57.33$ cm, $SD = 14.85$), compared to without tape ($M = 58.84$ cm, $SD = 15.97$), 95% CI [2.74, 0.28], *t* (20) = -2.56, $p < .05$ with a medium effect size (*d* = .56; see Figure 3). The difference scores for vertical jump height with and without tape were normally distributed, as assessed by Shapiro-Wilk's test ($p = .310$).

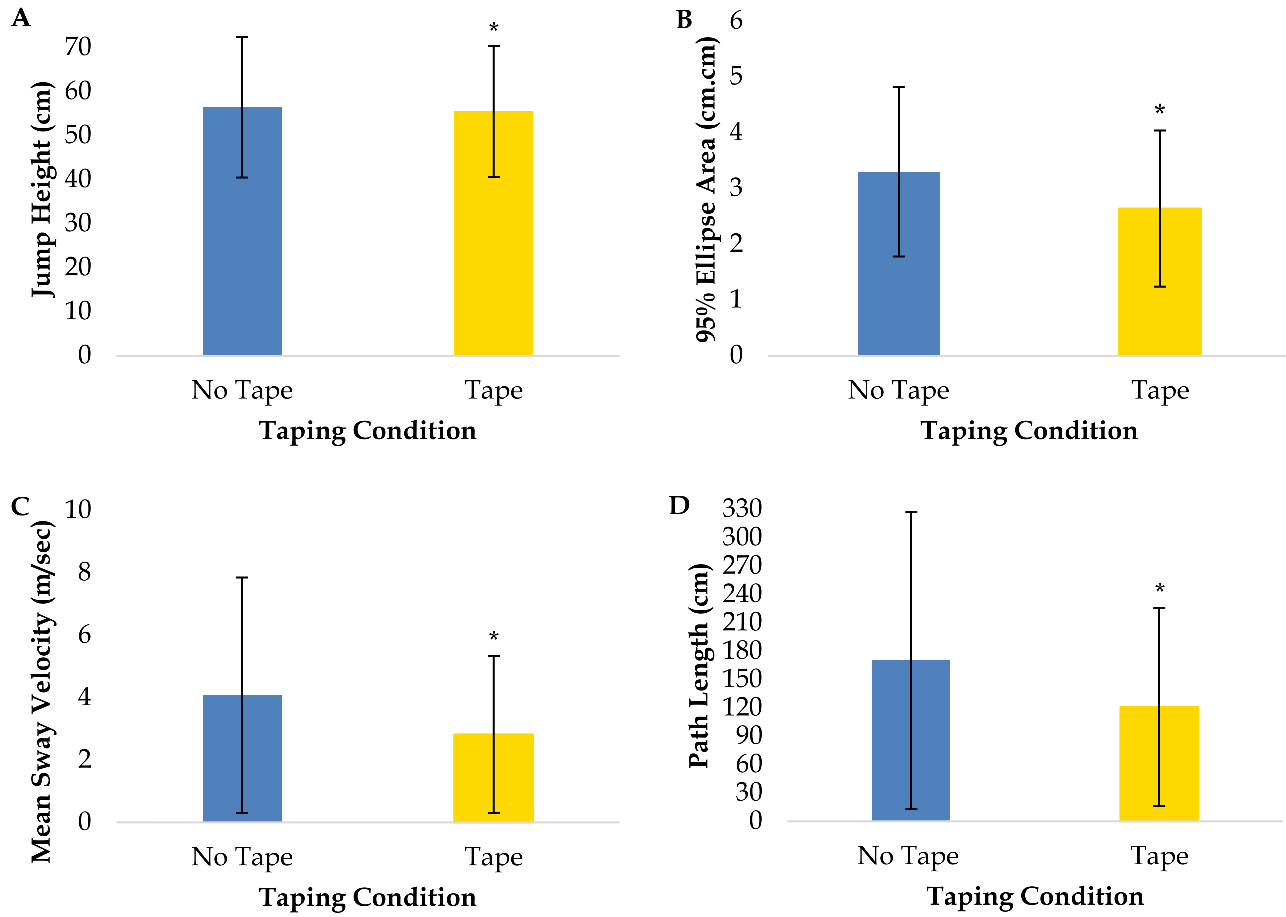

Figure 3. Differences across taping conditions for A) vertical jump height, B) 95% ellipses area, C) mean sway velocity, and D) path length. *Note.* * Indicates statistically significant difference from no tape condition ($p < .05$).

Mean Sway Velocity: There was a statistically significant decrease in mean sway velocity of 1.26 m/sec with tape (*M* = 2.82 m/sec, *SD* = 2.51), compared to without tape (*M* = 4.08 m/sec, *SD* = 3.77), 95% CI [7.47, 0.27], *t* (22) = -2.22, $p < .05$ with a medium effect size (*d* = .46; see Figure 3). The difference scores for mean sway velocity with and without tape were not normally distributed, as assessed by Shapiro-Wilk's test ($p < .001$). The results violated normality, however, a paired samples t-test is fairly robust to violations of normality with respect to Type I error.

Path Length: There was a statistically significant decrease in path length of 49.17 cm. with tape (*M* = 120.93 cm, *SD* = 104.85), compared to without tape (*M* = 170.10 cm, *SD* = 157.20), 95% CI [37.37, 1.33], *t* (22) = -2.23, $p < .05$ with a medium effect size (*d* = .46; see Figure 3). The difference scores for path length with and without tape were not normally distributed, as assessed by

Shapiro-Wilk's test (p < .001). The results violated normality, however, as mentioned above, a paired samples t-test is fairly robust to violations of normality with respect to Type I error.

95% Ellipse Area: There was a statistically significant mean decrease in 95% ellipse area of .66 cm.cm. with tape (M = 2.64 cm.cm, SD = 1.40), compared to without tape (M = 3.30 cm.cm, SD = 1.52), 95% CI [0.50, 0.02], t (22) = -2.26, p < .05 with a medium effect size (d = .58; see Figure 3). The difference scores for 95% ellipse area with and without tape were normally distributed, as assessed by Shapiro-Wilk's test (p = .222).

DISCUSSION

The purpose of this research was to examine the effects of ankle taping using zinc oxide tape versus no tape on measures of GRFs and vertical jump height during a sport-specific vertical jump in healthy youth basketball players. The current study was the first, to the best of the researcher's knowledge, to incorporate a sport-specific vertical jump test while examining the effects of ankle tape in youth basketball players. It was hypothesized that ankle taping would have similar effects to those discovered in previous literature while completing a sport-specific vertical jump test. The results of the current study confirmed the hypothesis that vertical jump height performance would decrease with the application of tape to the ankles, and ankle stability would increase. The results of the current study suggest that ankle taping can significantly affect jump height and GRFs during a vertical jump in a game-like situation in youth basketball players.

Vertical Jump Height: There was a statistically significant decrease in vertical jump height of 1.51 cm when the tape was applied compared to no ankle tape. This decrease in vertical jump height is in line with previous research by Bicici et al. (1). Bicici et al. (1) concluded that the application of ankle tape resulted in a significant decrease in performance on vertical jump height, however, other studies have concluded that there were minor or no effects on vertical jump height performance (20, 31). Ankle tape functions to restrict the ROM to provide external ankle support, limiting an individual's ability to vertically jump (31). Ankle taping has been proven as a valid prophylactic measure in preventing ankle sprains in basketball, however, its performance effects must be considered (31).

Although a mean decrease in jump height of 1.51 cm with ankle tape may not seem significant, in a game situation, it could represent the difference between blocking a shot, rebounding the ball, or not. Although some of the previous research has only concluded minor performance effects, ankle taping must be considered from a game perspective as a significant decrease or no decrease in jump height impacts basketball in different ways. The studies that found minor vertical jump performance effects suggest that ankle taping can be used as an effective prophylactic ankle sprain approach without negatively impacting vertical jump height (20, 31). Coaches, trainers, and athletes may see this as a benefit as they can support the ankle while still maintaining the same level of performance. On the contrary, results from Bicici et al. (1) suggest that ankle taping is an effective prophylactic approach, however, it may negatively impact an individual's jumping performance in a game situation.

Mean Sway Velocity: There was a statistically significant decrease in mean sway velocity of 1.26 m/sec with ankle tape compared to no tape. Additionally, it was noted that the results for mean sway velocity violated normality as the participant data was not normally distributed. Although each participant completed the procedures the same way, some individuals may have landed with greater force due to jumping capabilities. Males typically jump higher and with greater force (17). This was consistent with the results of the current study as the male participants typically jumped higher and landed with greater GRFs.

There is a lack of previous research examining sway velocity in vertical jump tests in basketball, however, one study examined GRFs in landing at various heights (27). Wei et al. (27) concluded that basketball players experienced greater impact loading, ankle ROM, and peak impact forces when landing. This may suggest that basketball players experience high GRFs and velocities at landing. A smaller sway velocity would imply that an individual swayed with less force per second in those directions and can, thus, stabilize the body more effectively (23). Greater velocity values in changes of COP indicate body position changes and greater ankle instability (23). Therefore, the results of this study suggested that individuals who wore ankle tape swayed less in the mediolateral and anteroposterior directions as the tape stabilized their ankles. Participants had higher sway velocities when performing the sport-specific jump without ankle tape, indicating less ankle stability and support than with tape. This further supports previous findings that ankle taping increased ankle stability by limiting the inversion and eversion ROM (28). By restricting the ankle's ROM with zinc oxide tape, the ankle ligamentous structures and muscles may be given adequate time to counteract the effect of the movement or sport specific task (24).

Path Length: There was a statistically significant decrease in path length of 49.17 cm. with ankle tape compared to no tape. The path length results of the current study suggest that the participant's distance travelled from the COP at landing was greater without ankle tape compared to with tape. Functional ankle instability has been reported in approximately 40% of individuals who sustain an ankle sprain (1). Ankle instability is associated with injury as individuals cannot effectively decrease their GRFs when combined with joint misalignment at landing (29). Previous research suggested that ankle taping can improve postural control and stability during any activity (13). The results of the current study indicate that the ankle taping condition increased ankle stability by decreasing the length travelled from the COP. From a basketball and vertical jumping perspective, previous studies have concluded that prophylactic ankle taping can restrict the ankle's ROM while not significantly affecting vertical jump performance (20). The results of this study further support previous research which suggested that taping restricts the ROM at the ankle joint. The decrease in path length of the current study indicated that the ankle did not travel as far from the COP at landing compared to without tape.

95% Ellipse Area: There was a statistically significant decrease in the 95% ellipse area of .66 cm.cm. with ankle tape compared to no tape. The 95% ellipse area data has been used to quantify postural balance over various populations and tasks, however, limited research exists for 95% ellipse area measures in vertical jump tests. The decrease seen in the results of the 95% ellipse area suggests that when participants landed with ankle tape, they had better postural balance and increased ankle stability than when not wearing tape at landing. A larger 95% ellipse area indicates greater deviation from the COP and poorer postural balance (22). Taping the ankle has also been shown to increase the stimulation of cutaneous mechanoreceptors to enhance proprioceptive input, influencing peroneal muscle activity which can contribute to the improved postural balance (13, 31). Additionally, Williams et al. (28) concluded that zinc oxide tape reduced the peak ankle inversion and ROM in all three planes of motion. This supports the results of this study, as the 95% ellipse area was smaller with tape than without, which suggests that the participants had less movement within the ankle's ROM and increased ankle stability.

Limitations: This study is not without some limitations that should be noted. Since this was an exploratory study, the analysis did not control for independent variables such as sex which could influence the results of this study. Males typically have a higher vertical jump height than females and the biomechanics of jumping and landing may vary by sex as well with different patterns used (17). The results of this study showed similar trends with the male participants typically jumping higher regardless of the taping condition.

Although the sport-specific vertical jump test was based on an established protocol, some limitations may have affected this study. The size of the force platform posed a limitation. Due to the participants completing a three-step sport-specific jump approach, there were trials where the participant did not land on the force platform properly. Additionally, the two-foot landing approach may have constrained the participants. In a game-like situation, basketball players do not have to focus on where and which foot to land on. This may have affected the mechanics of how the participants completed the jump, not fully allowing them to perform the vertical jump test the way they would have in an actual game situation.

Furthermore, with respect to not fully landing on the force platform, some participants were given an additional trial or two to ensure the researcher had valid results with two feet contacting the platform. This may have introduced familiarity with how to complete the sport-specific vertical jump and land more efficiently. Familiarity might have caused some participants to learn or modify their approach to jump higher if they received an additional trial. Additionally, since there was no randomization among the participants as to who had their ankles taped and who did not, this may have contributed to familiarity. Since all participants completed three trials without tape prior to with the tape, they may have had familiarity with the test and how to land with a more stable BOS.

Additionally, regarding the procedures was the facility's ceiling height restrictions as two participants were able to jump higher than the ceiling height. It was documented that these two individuals maxed out the ceiling height which may have affected the vertical jump height variable results as it did not accurately represent their jumping abilities.

One final limitation was the sample size collected. Based on the a priori power analysis, 28 participants were needed to achieve a power of .80. All efforts were made to try and recruit 28 participants to maintain a high power, however, due to time constraints and the COVID-19 pandemic affecting basketball participation, only 23 participants took part in the study. Although statistical significance was found for each dependent variable, having a more substantial power would have increased the probability of avoiding type II error and the accuracy of conclusions made from this study.

Future Considerations: The present study investigated the effects of ankle taping on measures of GRFs and vertical jump height during a sport-specific vertical jump in healthy youth basketball players. It was determined that the application of tape to the ankles resulted in a decreased jump height performance and an increase in ankle stability at landing. More comprehensive research is needed to support the results of this study. Furthermore, future research could determine the effects of various types of tapes, taping techniques, and tape properties after prolonged exercise on jumping performance and other basketball skills within the youth basketball population. Future research could also introduce randomization of the ankle taping condition to avoid familiarity among trials. Future research can also supplement the current literature available to determine the overall impact of taping as both a preventative and therapeutic method following inversion ankle sprains. In the meantime, any athlete, coach, or trainer should consider the benefits and the drawbacks of prophylactic ankle taping before participating in basketball with ankle tape to determine its utility and efficacy.

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