Journal of Biomechanics 90 (2019) 16–23

Contents lists available at ScienceDirect

Journal of Biomechanics

journal homepage: www.elsevier.com/locate/jbiomech
www.JBiomech.com

Effectiveness of taping on functional performance in elite athletes: A systematic review

Kenney Ki-Lee Lau *, Kenneth Chik-Chi Cheng

Department of Sports Science and Physical Education, Faculty of Education, The Chinese University of Hong Kong, Hong Kong

ARTICLE INFO

Article history:
Accepted 11 April 2019

Keywords:
Elastic tape
Rigid tape
Functional performance
Elite athlete
Professional athlete

ABSTRACT

Taping has been showing its effect on the rehabilitation aspect with numerous reviews. However, there is lack of evidence on the effect of taping on functional performance, especially in elite sports settings. This review aimed to evaluate the effectiveness of taping intervention on sports-related functional performance among the elite athlete population. Online databases such as Ovid MEDLINE, ProQuest, PubMed, ScienceDirect, Scopus, SPORTDiscus, and Web of Science were searched. Eligibility criteria were listed as follows: (i) English, (ii) academic journal, (iii) research article, (iv) elite or professional athletes, (v) experimental research design, (vi) sport, (vii) taping, and (viii) functional performance. Specific emphases were targeted on within-subject comparison and healthy subjects. The PEDro scale was utilized for appraising on the statistical information, as well as internal and external validity. The Cohen's d effect size with 95 percent confidence intervals was used to compare taped versus not-taped condition. Nine studies were included in this review and 25 comparisons were extracted. Positive effects were found on balance performance with rigid tape, and horizontal jump performance with elastic tape. Alternatively, negative effects were found on vertical jump performance. An interesting finding was noted on the effect of taping applied after 24 h. Overall, taping could be a beneficial practice for elite sports performance.

1. Introduction

Taping technique is not something extraordinary within the sports domain. Its footprint was widespread in different sports and already exploited by some eminent athletes, for instances Cristiano Ronaldo in football (McNamara, 2016), James Harden in basketball (Pollakoff, 2015), Li Na in tennis (Salzberg, 2014), Lee Chong Wei in badminton (Ram, 2016), and Kerri Walsh Jennings in beach volleyball (Fields, 2016). Notwithstanding the foregoing prevalence, the justification for taping did not have a solid scientific foundation.

The effects of taping in sports were still an ongoing debate in academia. Protests have declined its effects on neither musculoskeletal injury (Mostafavifar et al., 2012; Parreira et al., 2014; Lim and Tay, 2015; Montalvo et al., 2015), nor spinal pain and disability (Vanti et al., 2015). Alternatively, advocacies have recommended on patellofemoral pain syndrome (Aminaka and Gribble, 2005; Barton et al., 2014; Chang et al., 2015; Logan et al., 2017), subacromial impingement syndrome (McLaren et al., 2016; Saracoglu et al., 2018), rotator cuff tendinopathy (Desjardins-Charbonneau et al., 2015), and chronic low back pain (Nelson, 2016). Nonetheless, the consensus was not compromised yet, some evidence could still insinuated the influence of taping on rehabilitation extent. As for its therapeutic usage, it could be principally established on top of the theoretical basis (Jacobs and Austin, 2014; Peterson and Renstrom, 2017).

Apart from the impact of taping on the recovery of musculoskeletal disorders, scholars have suggested an alternate perspective regarding sports performance enhancement (Bandyopadhyay and Mahapatra, 2012; Pysny et al., 2015). However, dissent claimed that it was just a kind of psychological help (Vercelli et al., 2012). Existing literature has already engaged in discovering the effects of taping on sport-related functional performance. Consideration of this measure could be recognized as it was symbolic of athletic performance (Lockie et al., 2015). Inspections of rigid tape did not indicate any proof, no matter on balancing (Abian-Vicen et al., 2008; Hopper et al., 2009; Bicici et al., 2012; Halim-Kertanegara et al., 2017) or jumping (Lee, 2004; Abian-Vicen et al., 2008; Bicici et al., 2012; Halim-Kertanegara et al., 2017). On the other hand, examination of elastic tape has also tested with

* Corresponding author at: Department of Sports Science and Physical Education, Kwok Sports Building, The Chinese University of Hong Kong, Shatin, New Territories, Hong Kong.
E-mail address: kenney.kl.lau@link.cuhk.edu.hk (K.K.-L. Lau).

https://doi.org/10.1016/j.jbiomech.2019.04.016
0021-9290/

balance (Bicici et al., 2012; Ahn et al., 2015; Basturk et al., 2015; Lins et al., 2016; Oliveria et al., 2016; Lee and Lee, 2017), jump (Huang et al., 2011; Bicici et al., 2012; Basturk et al., 2015; Chaney et al., 2015; Cheung et al., 2016; Lins et al., 2016; Strutzenberger et al., 2016), and sprint speed (Basturk et al., 2015; Chaney et al., 2015; Ozmen et al., 2016; Strutzenberger et al., 2016). Nevertheless, barely the studies of Alghamdi and Shawki (2018), Trecroci et al. (2017), and Ahn et al. (2015) have shown positive effects on horizontal jump, sprint cycling speed, and balance performance. Despite the utility of taping on functional performance still being questioned (Reneker et al., 2017), appetence for further commentary about different types of tape on functional performance was demanded, so as to grant a comprehensive interpretation.

In the pathway of chasing sports performance, there is a group of people who aim it as career goal. Elite athletes are no doubt the most demanding population on mastering the sports skills thoroughly. To resume, subjects from the studies mentioned above were mainly participating in recreational sports or lacking intensive sports training background, and results from these studies cannot be generalized in the elite sports setting. By way of example, conditioning and coordination capacities were cases of the main physical difference from elites to recreational athletes (Serrano et al., 2013). In fact, elite athletes achieved the highest standard of performance, success and experience at the highest sporting level (Swann et al., 2015), which behaved differently from the general population. Consequently, a unique emphasis on performance-related intervention in elite sports was expected.

In brief, the systematical review on performance effects of taping in elite sports was desired. Present review aimed to evaluate the effectiveness of taping intervention on functional performance in elite athlete samples. The operational definition of taping was to use elastic tape or rigid tape. Functional performance was operationally defined as balance, horizontal jump, vertical jump, sprint speed, and wrist strength performance. Elite athlete was defined as regional, national, or professional track and field, ball sports, and martial arts player.

2. Methods

2.1. Protocol

The present review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, PRISMA (Liberati et al., 2009; Moher et al., 2009).

2.2. Eligibility criteria

Studies included in the present review were based on the following inclusion criteria: (i) English language, (ii) academic journal publication, (iii) research article, (iv) elite or professional athlete subjects, (v) experimental research design, (vi) sports discipline, (vii) taping intervention, and (viii) functional performance measurement. In addition, studies were excluded if it only provided the English version for abstract or was the study protocol.

2.3. Information sources

Electronic search through online databases included MEDLINE, ProQuest, PubMed, ScienceDirect, Scopus, SPORTDiscus, and Web of Science. Following search terms were used to identify the potential studies: (I) "taping" or "tape", (II) "sport" or "sports", and (III) "elite" or "professional". Last searches were run on 2nd February 2018.

2.4. Study selection

Search records were cross-referenced by means of all databases. Duplicate references were removed in advance of the screening procedure. The selection process has undergone a series of checking, started with the title first, followed by the abstract, and then the full text. Two independent reviewers carried out references screening. Discussion between reviewers was conducted to settle any discrepancies, in order to determine the inclusion of studies for the present review.

2.5. Data collection process

A standardized form was used to acquire information from each included study. Data extraction was performed by principal reviewer. When the data of the study were not sufficient, the corresponding author was contacted via electronic mail in request of missing data.

2.6. Data Items

Background information contained methodology (type of functional performance test and intermediate period among conditions), participants (skill level, sport participated, and location of participation), and intervention (type of tape, taping location, and duration of effect tested). Statistical data involved the outcome measures (sample size, mean, and standard deviation). Comparisons were focused on the taped condition, comparing to the not-taped condition. Specific emphases were targeted on healthy subjects and within-subject comparison.

2.7. Risk of bias in individual studies

The PEDro scale was utilized for evaluation of the included studies (Verhagen et al., 1998), which consisted of 11 standards appraising the sufficiency of statistical information, as well as the internal and external validity. Points were only given when the criterion clearly pleased. Mean score and standard deviation for all included studies was reported. In addition, the passing rate for each criterion was introduced, which was defined as the number of studies passing the criterion over the total number of studies.

2.8. Summary measures

The Cohen's d effect size with 95 percent confidence intervals was the primary measure in comparing the taped condition to the not-taped condition, where significance was considered when 95 percent confidence intervals of effect size did not encompass zero. Positive effect size indicated superior performance in taped condition, yet negatively implied an advanced performance in not-taped condition. Interpretation of effect size magnitude was as follows (Cohen, 1988): 0.2 as a small effect, 0.5 as a moderate effect, and 0.8 as a large effect. The tool of data analysis has employed the spreadsheet (i.e. Microsoft Excel) created by the Centre for Evaluation and Monitoring (2018). Data were calculated by using built-in formulas. The effect size was computed as the mean difference between taped condition and not-taped condition within a single comparison, divided by the pooled estimate of standard deviation from both conditions. Confidence intervals were computed as effect size plus-minus the z-value multiplied by the standard error of the effect size estimate.

3. Results

3.1. Study selection

The database search has initially retrieved 382 citations and then 236 were left after duplicates were removed. Two hundred and twenty-six references were excluded owing to dissatisfaction of the eligibility criteria. Reasons of exclusion were: (a) not studied elite or professional athletes, (b) not related to sport, (c) not experimental research design, (d) not journal article, (e) not tested functional performance, and (f) not related to taping technique. Two more references were excluded due to insufficient descriptive statistics reported, while one extra reference was identified through another source (i.e. the university library online search engine). Nine studies were eventually confirmed for the present review (Sanioglu et al., 2009; Jeffriess et al., 2015; Momtazfar et al., 2015; Someeh et al., 2015a, 2015b; Schiffer et al., 2015; Bailey and Firth, 2017; Gloria et al., 2017; Henderson et al., 2017). A flow diagram described full procedures was shown in Fig. 1.

3.2. Studies characteristics

Nine studies showed a great deal of variety in terms of their sample size, sports involved, and outcome measurements (see Table 1). In the type of functional performance tests, there were two studies on balance (Someeh et al., 2015a; Bailey and Firth, 2017), three studies on horizontal jump (Someeh et al., 2015b; Schiffer et al., 2015; Gloria et al., 2017), two studies on vertical jump (Sanioglu et al., 2009; Henderson et al., 2017), one study on sprint speed (Jeffriess et al., 2015), and one study on wrist strength (Momtazfar et al., 2015). As for the level of elites, five study samples were professional athletes (Jeffriess et al., 2015; Someeh et al., 2015a, 2015b; Bailey and Firth, 2017; Gloria et al., 2017), two study samples were from national team (Sanioglu et al., 2009; Schiffer et al., 2015), one was from the highest university division (Henderson et al., 2017), and one was elites with repetitive and vigorous practice and competition (Momtazfar et al., 2015). As for the interventions, five studies examined with elastic tape (Momtazfar et al., 2015; Schiffer et al., 2015; Bailey and Firth, 2017; Gloria et al., 2017; Henderson et al., 2017), while four studies were on rigid tape (Sanioglu et al., 2009; Jeffriess et al., 2015; Someeh et al., 2015a, 2015b). Moreover, six studies targeted at joint taping that specifically focused on ankle position (Sanioglu et al., 2009; Jeffriess et al., 2015; Someeh et al., 2015a, 2015b; Bailey and Firth, 2017; Henderson et al., 2017), and other three studies aimed at muscle taping (Momtazfar et al., 2015; Schiffer et al., 2015; Gloria et al., 2017).

3.3. Risk of bias within studies

Mean score (±standard deviation) of the assessment by PEDro scale for all included studies was 6.4 (±1.51) out of 11, with the range from 4 to 9 (see Table 2). Two studies could not meet half of the full score (Sanioglu et al., 2009; Momtazfar et al., 2015). Relatively poor attainments of criteria were reported as follows. Forty-four percent of studies contented point measures and measures of variability (C11), five studies presented sufficient statistical information (Sanioglu et al., 2009; Jeffriess et al., 2015; Momtazfar et al., 2015; Schiffer et al., 2015; Gloria et al., 2017). Twenty-two percent of studies (Bailey and Firth, 2017; Gloria et al., 2017) merely managed to conceal of subject allocation (C3). Eleven percent of studies (Gloria et al., 2017) exclusively handled the blinding of subjects (C5). None of the studies dealt with the blinding of therapists (C6).

3.4. Results of individual studies

Summarized outcomes manifested in a total of 25 comparisons, where twelve comparisons used elastic tape (see Table 3) and thirteen comparisons used rigid tape (see Table 4). The effect size of each comparison was calculated individually. Overall effect size did not apply to the present review due to the distinct variations of outcome measure among different performance tests.

3.4.1. Elastic tape

No effect was shown in balance performance (Bailey and Firth, 2017). Contrary, a large negative effect ($d = -1.69$) was reflected in the vertical jump (Henderson et al., 2017). Besides, large positive effects were displayed in the single horizontal jump for the post-test at immediate ($d = 0.92$) and 24h ($d = 1.46$) time points (Gloria et al., 2017). Although no effect was indicated in immediate effect of the triple horizontal jump, surprisingly a large positive

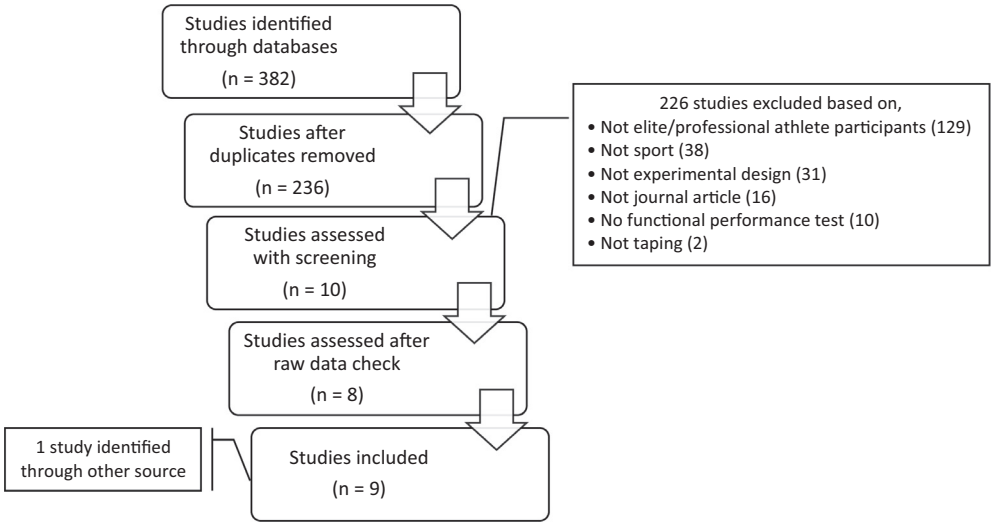

Fig. 1. The flow diagram of study selection procedures.

Table 1
Overview of included studies.

	Methodology		Participants			Intervention		
Study	Test	Interval	Skill level	Sport	Origin	Tape	Location	Effect(s)
Sanioglu et al., 2009	Vertical jump	5 min	National	Taekwondo	Turkey	Rigid	Ankle	Immediate
Jeffriess et al., 2015	Sprint Speed	2 days	Professional	Basketball	Australia	Rigid	Ankle	Immediate
Momtazfar et al., 2015	Hand strength	At least 3 days	Elite	Karate	Iran	Elastic	Wrist	Immediate & 24 h
Schiffer et al., 2015	Horizontal jump	45 min	National	Track and Field	Germany	Elastic	Multi	Immediate
Someeh et al., 2015a	Balance	10 min	Professional	Ball Sports	Iran	Rigid	Ankle	Immediate
Someeh et al., 2015b	Horizontal jump	10 min	Professional	Ball Sports	Iran	Rigid	Ankle	Immediate
Bailey & Firth, 2017	Balance	Minimum 1 week	Professional	Football	United Kingdom	Elastic	Ankle	Immediate
Gloria et al., 2017	Horizontal jump	30 min	Professional	Football	Brazil	Elastic	Rectus femoris	Immediate & 24 h
Henderson et al., 2017	Vertical jump	At least 1 day	University Division I	American Football	United States	Elastic	Ankle	Immediate

Note. Multi = gastrocnemius, hamstring, rectus femoris, and iliopsoas.

Table 2
Methodological quality assessment.

Study	Score	EV	IV							SI	
		C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11
Sanioglu et al., 2009	5	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	No
Jeffriess et al., 2015	7	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No
Momtazfar et al., 2015	4	No	No	No	Yes	No	No	No	Yes	Yes	Yes	No
Schiffer et al., 2015	7	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	No
Someeh et al., 2015a	6	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes
Someeh et al., 2015b	6	No	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes
Bailey & Firth, 2017	9	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Gloria et al., 2017	6	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No	No
Henderson et al., 2017	8	Yes	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Number of studies pass		5	7	2	9	1	0	5	8	9	8	4
Passing rate		56%	78%	22%	100%	11%	0%	56%	89%	100%	89%	44%

Note. EV = external validity; IV = internal validity; SI = statistical information; C1 = Eligibility criteria were specified; C2 = Subjects were randomly allocated an order in which treatments were received; C3 = Allocation was concealed; C4 = The groups were similar at baseline regarding the most important prognostic indicators; C5 = There was blinding of all subjects; C6 = There was blinding of all therapists who administered the therapy; C7 = There was blinding of all assessors who measured at least one key outcome; C8 = Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; C9 = All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"; C10 = The results of between-group statistical comparisons are reported for at least one key outcome; C11 = The study provides both point measures and measures of variability for at least one key outcome. Copyright 1998 by Verhagen et al.

Table 3
Statistics of included studies in elastic tape condition.

Measure (Study)	Taped condition (Elastic)				Not-taped condition				Cohen's d		
	Group	N	M	SD	Group	N	M	SD	ES	CI Lower	CI Upper
Accuracy score in balance control (Bailey & Firth, 2017)	/	20	56.30	16.3	/	20	52.00	16.9	0.26	−0.36	0.88
Height in vertical jump (Henderson et al., 2017)	/	29	76.20	1.30	/	29	78.40	1.30	**−1.69**	**−2.29**	**−1.09**
Distance in single leg hop (Gloria et al., 2017)	Imm	12	1.92	0.12	Base	12	1.81	0.12	**0.92**	**0.08**	**1.76**
	24 h	12	2.00	0.14	Base	12	1.81	0.12	**1.46**	**0.56**	**2.36**
Distance in single leg triple hop (Gloria et al., 2017)	Imm	12	5.84	0.37	Base	12	5.67	0.45	0.41	−0.40	1.22
	24 h	12	6.04	0.39	Base	12	5.67	0.45	**0.88**	**0.04**	**1.72**
Distance in single leg double hop (Schiffer et al., 2015)	TL2	18	4.13	0.17	C	18	4.08	0.21	0.26	−0.39	0.92
	TL2	18	4.13	0.17	TL1	18	4.06	0.18	0.40	−0.26	1.06
Power in wrist flexor (Momtazfar et al., 2015)	Imm	11	38.54	4.63	Base	11	32.72	9.41	0.78	−0.08	1.65
	24 h	11	33.90	7.54	Base	11	32.72	9.41	0.14	−0.70	0.98
Power in wrist extensor (Momtazfar et al., 2015)	Imm	11	18.72	6.35	Base	11	14.00	4.69	0.85	−0.03	1.72
	24 h	11	19.27	4.65	Base	11	14.00	4.69	**1.13**	**0.23**	**2.03**

Note. Imm = immediate; Base = baseline; 24 h = after 24 h; TL = tested leg; C = control.
Significant difference highlighted in bold.

effect (d = 0.88) was represented at 24h post-test (Gloria et al., 2017). But no effects were illustrated in the double horizontal jump (Schiffer et al., 2015). A large positive effect (d = 1.13) on wrist extension strength at 24h time point was denoted, but not on the other three conditions from the same study (Momtazfar et al., 2015).

3.4.2. Rigid tape

No significant effects were found on balance in overall and three different directions (Someeh et al., 2015a), vertical jump in both genders (Sanioglu et al., 2009), horizontal jump in various tasks (Someeh et al., 2015b), and planned or random direction sprint speed (Jeffriess et al., 2015).

Table 4
Descriptive statistics of included studies in rigid tape condition.

Measure (Study)	Taped condition (Rigid)				Not-taped condition				Cohen's d		
	Group	N	M	SD	Group	N	M	SD	ES	CI Lower	CI Upper
Maximum excursion distance in star excursion balance (Someeh et al., 2015a)	OA	16	318.60	15.60	OA	16	310.10	16.70	0.53	−0.18	1.23
	ML	16	106.90	6.30	ML	16	103.90	7.20	0.44	−0.26	1.14
	AM	16	100.50	5.40	AM	16	98.90	5.00	0.31	−0.39	1.00
	PM	16	111.10	6.80	PM	16	107.20	7.70	0.54	−0.17	1.24
Height in vertical jump (Sanioglu et al., 2009)	W	7	44.25	5.44	W	7	46.75	5.50	−0.46	−1.52	0.60
	M	9	64.33	2.73	M	9	65.83	3.06	−0.52	−1.46	0.42
Time in hop course (Someeh et al., 2015b)	/	16	6.91	1.00	/	16	7.43	0.99	0.52	−0.18	1.23
Time in figure-of-8 hop (Someeh et al., 2015b)	/	16	4.14	0.40	/	16	4.36	0.50	0.49	−0.22	1.19
Time in side hop (Someeh et al., 2015b)	/	16	7.22	1.09	/	16	7.60	1.18	0.33	−0.36	1.03
Time in planned direction sprint (Jeffriess et al., 2015)	L	20	1.96	0.13	L	20	1.95	0.09	−0.09	−0.71	0.53
	R	20	1.95	0.15	R	20	1.98	0.16	0.19	−0.43	0.81
Time in reactive agility sprint (Jeffriess et al., 2015)	L	20	2.72	0.12	L	20	2.77	0.17	0.34	−0.28	0.96
	R	20	2.75	0.17	R	20	2.75	0.19	0.00	−0.62	0.62

Note. OA = overall; ML = medial; AM = anteromedial; PM = posteromedial; W = Women; M = Men; L = left; R = right.

4. Discussion

Present review anticipated to integrate current evidence measuring the effects of taping technique on various sports performance such as balance, vertical jump height, horizontal jump distance and speed, wrist strength and sprint speed performance in elite athlete population. A comprehensive investigation of this theme work may lead to an influential understanding, targeted on the evolution of sports medicine in promoting athletic performance via non-intrusive intervention for the elites.

4.1. Risk of bias across studies

Attention should also be paid on the washout period as there was a possibility of carryover effect in case the time between the tests was not enough. Elaboration of methodological quality assessment was separated into advantages and disadvantages.

Superiority has flaunted in similar subjects at baseline (C4), which was in merit to the within-subject comparison. Studies executed the randomization of test conditions (C2) and allocation of the control condition (C9) were the fortes and essential elements for a randomized controlled trial. Most studies did clearly report between group statistical results (C10), for example, the p-value, mean difference, and hazard ratio. The majority also did maintain the sample size (C8) throughout the project that no significant data loss issues happened.

Conversely, studies did not compromise external validity (C1) mainly because they did not state the source of subjects. Matter on blinding of assessors (C7) was the problem of study design, as it requires a third person to help with reducing the possible prejudice during the data collection. More detailed statistics were encouraged to enclose the point measures (i.e. effect size) and measures of variability (C11), such as standard deviation and confidence intervals. Mask of subject allocation (C3) was commonly not depicted. It is suggested that either the person who draws the orders need to be other than the examiner, or keep the orders in sealed opaque envelopes (Doig and Simpson, 2005). Subject blinding (C5) was proposed to adopt the sham condition for improvement, in order to prevent the subject to be aware of the intervention, thus mentally affected the test results. Lastly, it was judged as not applicable in blinding of therapists (C6), because the therapist must have to know whether the subject needed to be taped or not, or the way to tape.

4.2. Balance

Although no significant effects were suggested on both tapes in the present review, there were significant differences on rigid tape pointed in the original study (Someeh et al., 2015a). The underlying mechanism of balance performance in sport was based on ankle proprioception. Since the foot is the only body part contacting the ground during sport, proprioception enables adjustment of ankle position and upper extremity motion to perform various motor tasks (Han et al., 2015). As an illustration, postural control was contributed to the change of movement directions (Bird and Markwick, 2016). Contact sports athlete like soccer, handball, and basketball has proved the correlation between balance and agility (Sekulic et al., 2013). Athletes of non-contact sport like golf, softball, and volleyball could be beneficial because the sport-specific training may not engage many efforts on balance ability (Vitale et al., 2018). Meanwhile, Alghamdi and Shawki (2018) did reflect statistical improvement in the static balance test using elastic tape. A possible downside for this result was that promoting balance performance may claim more restriction pressure. Perhaps a stronger tension can help for this shortage in elastic tape.

4.3. Vertical jump

Significant negative effect was found on elastic tape condition in the present review (Henderson et al., 2017), and significant difference was exposed on rigid tape in the original study (Sanioglu et al., 2009). It could be imputed that the taping technique restricted the joint range of motion in the frontal and sagittal planes (Quirke and Harrison, 2002), thus this restriction would significantly decrease the height in vertical jumping (Haguenauer et al., 2006). Sports requiring explosive powering may possibly be disadvantaged (Kobal et al., 2017). Literature till nowadays had announced negatively on vertical jump performance no matter in elastic tape (Huang et al., 2011; Bicici et al., 2012; Hoyo et al., 2013; Basturk et al., 2015; Chaney et al., 2015; Cheung et al., 2016; Strutzenberger et al., 2016), or rigid tape (Abian-Vicen et al., 2008; Bicici et al., 2012).

4.4. Horizontal jump

Significant positive effects were found on elastic tape condition for horizontal jump distance (Gloria et al., 2017). It was believed that sample size (n = 16) was a reason for rigid tape measurement not acquiring significant results in the present review, as significant differences had proclaimed in the original study (Someeh et al., 2015b). Ahn et al. (2015) and Alghamdi and Shawki (2018) did claim significant positive effects of rigid taping, where 45 and 30 participants were used. Noted that advantage was on single muscle taping (Gloria et al., 2017), but not multi-muscle groups and joint taping (Schiffer et al., 2015; Someeh et al., 2015b). A

surprising result declared the effect of taping was more obvious in 24 h later comparing to the immediate testing (Gloria et al., 2017). It may credit to the rehabilitation function of taping technique for better recovery (Zulfikri and Justine, 2017).

4.5. Wrist strength

Albeit significant positive effect was demonstrated on extension strength in the wrist with elastic tape at 24 h time point (Momtazfar et al., 2015), deliberation should be taken with drawbacks of the study. The study of Momtazfar et al. (2015) obtained the worst methodological quality among other studies in the present review. Non-randomized study design may also be blamed. Rudimentary reason for the effect may be noticed that subjects were karate athletes, there were a lot of movements incorporating front arms so that it is feasible to them in case of the excessive training. Hoyo et al. (2013) also found nothing on extension strength in legs with elite football players. Rare documents had mentioned the connection between power performance and sport. This circumstance was probably due to the reliance on strength training from the beginning athletic stage.

4.6. Sprint speed

Taping has no effects on sprint speed (Jeffriess et al., 2015), which coincided with previous findings on non-elite population (Hoyo et al., 2013; Basturk et al., 2015; Chaney et al., 2015; Ozmen et al., 2016; Strutzenberger et al., 2016). The assertion could be made that elastic tape did not affect sprint speed performance.

4.7. Practical applications

Immediate performance enhancement may be considered for balance using Mulligan's fibular reposition technique with rigid tape in the ankle (Moiler et al., 2006). Furthermore, Kase's muscle activation technique with elastic tape on rectus femoris could be introduced for immediate improvement of horizontal jump (Kase et al., 2013). For multiple taping locations, the effects may be counteracted between muscle groups, leading to neutralization of the facilitation effect. Avoidance is recommended on not to make use of any tapes in the ankle joint for vertical jump performance.

4.8. Limitation

Difficulties were confronted in comparing different taping methods and different tapes, since taping technique, taping location, and nature of tape were varied. Difference in sports performance measurement was also the weakness for generalizing insight on particular variables.

5. Conclusion

The present review had summarized the effectiveness of taping on functional performance of balance, vertical jump, horizontal jump, wrist strength, and sprint speed in elite athletes. Positive effects were found on balance and horizontal jump performance associated with the use of rigid tape and elastic tape respectively. In contrast, negative effects were found on vertical jump performance with both tapes. An interesting effect was remarked on the effect of taping applied after 24 h. Several issues cannot be neglected when interpreting the results, touch upon elements of taping methods like location and technique, characteristic of subjects as the participated sport, and research design on blinding issues. Future exploration could be concentrated on types of tape, taping technique, taping location, as well as taping effect duration.

Conflict of interest

The authors declare that they have no conflict of interest.

Acknowledgment

Principal author would like to express the deep gratitude to Ms. Lucinda Wing-Lam Kam and Dr. Johan Yau-Yin Ng for the voluntary manuscript writing consultation.

References

Alghamdi, A., Shawki, M., 2018. The effect of kinesio taping on balance control and functional performance in athletes with chronic ankle instability. MedCrave Online J. Orthop. Rheumatol. 10 (2), 114–120. https://doi.org/10.15406/mojor.2018.10.00398.

Ahn, I.K., Kim, Y.L., Bae, Y.H., Lee, S.M., 2015. Immediate effects of kinesiology taping of quadriceps on motor performance after muscle fatigued induction. Evidence-Based Complement. Alternat. Med. https://doi.org/10.1155/2015/410526.

Abian-Vicen, J., Alegre, L.M., Fernandez-Rodriguez, J.M., Lara, A.J., Meana, M., Aguado, X., 2008. Ankle taping does not impair performance in jump or balance tests. J. Sports Sci. Med. 7, 350–356.

Aminaka, N., Gribble, P.A., 2005. A systematic review of the effects of therapeutic taping on patellofemoral pain syndrome. J. Athletic Train. 40 (4), 341–351.

Bandyopadhyay, A., Mahapatra, D., 2012. Taping in sports: a brief update. J. Human Sport Exerc. 7 (2), 544–552. https://doi.org/10.4100/jhse.2012.72.17.

Barton, C., Balachandar, V., Lack, S., Morrissey, D., 2014. Patellar taping for patellofemoral pain: a systematic review and meta-analysis to evaluate clinical outcomes and biomechanical mechanisms. Br. J. Sports Med. 48, 417–424. https://doi.org/10.1136/bjsports-2013-092437.

Bailey, D., Firth, P., 2017. Does kinesiology taping of the ankles affect proprioceptive control in professional football (soccer) players. Phys. Therapy Sport 25, 94–98. https://doi.org/10.1016/j.ptsp.2016.09.001.

Basturk, D., Gokdemir, K., Kaya, M., Unuvar, B.S., Taskin, H., Erkmen, N., 2015. Effect of kinesio taping on functional performance in football players. Sport Sci. Pract. Asp. 12 (2), 39–44.

Bicici, S., Karatas, N., Baltaci, G., 2012. Effect of athletic taping and kinesiotaping on measurements of functional performance in basketball players with chronic inversion ankle sprains. Int. J. Sports Phys. Therapy 7 (2), 154–166.

Bird, S.P., Markwick, W.J., 2016. Musculoskeletal screening and functional testing: considerations for basketball athletes. Int. J. Sports Phys. Therapy 11 (5), 784–802.

Chaney, C., Hirayama, G.M., Mendoza, T.E., Schmitt, D.M., Janini, S., 2015. The effects of Kinesio tape on vertical jump, 20-m sprint, and self-perception of performance in high school basketball players. Curr. Orthop. Pract. 26 (4), 420–424. https://doi.org/10.1097/BCO.0000000000000253.

Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences. Erlbaum Associates, United States.

Cheung, T.H., Yau, K.C., Wong, K., Lau, P., So, A., Chan, N., Kwok, C., Poon, K.Y., Yung, S.H., 2016. Kinesiology tape does not promote vertical jumping performance: a deceptive crossover trial. Manual Therapy 21, 89–93. https://doi.org/10.1016/j.math.2015.06.001.

Chang, W.D., Chen, F.C., Lee, C.L., Lin, H.Y., Lai, P.T., 2015. Effects of Kinesio taping versus McConnell taping for patellofemoral pain syndrome: a systematic review and meta-analysis. Evidence-Based Complement. Alternat. Med. https://doi.org/10.1155/2015/471208.

Centre for Evaluation and Monitoring, 2018. Effect Size Calculator. <https://www.cem.org/effect-size-calculator>.

Desjardins-Charbonneau, A., Roy, J.S., Dionne, C.E., Desmeules, F., 2015. The efficacy of taping for rotator cuff tendinopathy: a systematic review and meta-analysis. Int. J. Sports Phys. Therapy 10 (4), 420–433.

Doig, G.S., Simpson, F., 2005. Randomization and allocation concealment: a practical guide for researchers. J. Crit. Care 20, 187–193. https://doi.org/10.1016/j.jcrc.2005.04.005.

Fields, J., 2016. What's that colorful tape on the beach volleyball players? It's kinesio tape. Here's how it works. The Denver Post. <http://www.denverpost.com/2016/08/10/what-is-kinesio-tape>.

Gloria, P.S., Politti, F., Leal, C.P., Lucareli, R.G., Herpich, C.M., Antonialli, F.C., Gomes, F.P., 2017. Kinesio taping does not alter muscle torque, muscle activity or jumping performance in professional soccer players: a randomized, placebo-controlled, blind, clinical trial. J. Back Musculoskelet. Rehabil. 30, 869–877. https://doi.org/10.3233/BMR-160556.

Huang, C.Y., Hsieh, T.H., Lu, S.C., Su, F.C., 2011. Effect of the Kinesio tape to muscle activity and vertical jump performance in healthy inactive people. Biomed. Eng. Online 10 (70). https://doi.org/10.1186/1475-925X-10-70.

Hopper, D., Samsson, K., Hulenik, T., Ng, C., Hall, T., Robinson, K., 2009. The influence of Mulligan ankle taping during balance performance in subjects with unilateral

chronic ankle instability. Phys. Therapy Sport 10, 125–130. https://doi.org/10.1016/j.ptsp.2009.07.005.
Han, J., Anson, J., Waddington, G., Adams, R., Liu, Y., 2015. The role of ankle proprioception for balance control in relation to sports performance and injury. BioMed Res. Int. https://doi.org/10.1155/2015/842804.
Henderson, J., Lyons, B.C., Tucker, W.S., Davidson, B., 2017. Comparison of prophylactic ankle cloth wrapping and taping on vertical jump height in division I football players. Int. J. Athletic Therapy Train. 22 (6), 40–45. https://doi.org/10.1123/ijatt.2016-0106.
Hoyo, M., Alvarez-Mesa, A., Sanudo, B., Carrasco, L., Dominguez, S., 2013. Immediate effect of Kinesio taping on muscle response in young elite soccer players. J. Sport Rehabil. 22, 53–58.
Haguenauer, M., Legreneur, P., Monteil, K.M., 2006. Influence of figure skating skates on vertical jumping performance. J. Biomech. 39, 699–707. https://doi.org/10.1016/j.jbiomech.2005.01.005.
Halim-Kertanegara, S., Raymond, J., Hiller, C.E., Kibreath, S.L., Refshauge, K.M., 2017. The effect of ankle taping on functional performance in participants with functional ankle instability. Phys. Therapy Sport 23, 162–167. https://doi.org/10.1016/j.ptsp.2016.03.005.
Jacobs, M.A., Austin, N.M., 2014. Taping Techniques. In: Orthotic Intervention for the Hand and Upper Extremity: Splinting Principles and Process. Lippincott Williams and Wilkins, United States, pp. 355–356s.
Jeffriess, M.D., Schultz, A.B., McGann, T.S., Callaghan, S.J., Lockie, R.G., 2015. Effects of preventative ankle taping on planned change-of-direction and reactive agility performance and ankle muscle activity in basketballers. J. Sports Sci. Med. 14, 864–876.
Kase, K., Wallis, J., Kase, T., 2013. Clinical Therapeutic Applications of Kinesio Taping Method. Kinesio Taping Association International, Tokyo.
Kobal, R., nakamura, F.Y., Kitamura, K., Abad, C.C., Pereira, L.A., Loturco, I., 2017. Vertical and depth jumping performance in elite athletes from different sports specialties. Sci. Sports 32, 191–196. https://doi.org/10.1016/j.scispo.2017.01.007.
Lins, A.A., Borges, D.T., Macedo, L.B., Costa, S.A., Brasileiro, J.S., 2016. Delayed effect of Kinesio Taping on neuromuscular performance, balance, and lower limb function in healthy individuals: a randomized controlled trial. Br. J. Phys. Therapy 20 (3), 231–239. https://doi.org/10.1590/bjpt-rbf.2014.0161.
Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gotzsche, P.C., Loannidis, P.A., Clarke, M., Devereaux, P.J., Kleijnen, J., Moher, D., 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. PLoS Med. 6 (7). https://doi.org/10.1371/journal.pmed.1000100.
Logan, C.A., Bhashyam, A.R., Tisosky, A.J., Haber, D.B., Provencher, M.T., 2017. Systematic review of the effect of taping techniques on patellofemoral pain syndrome. Sports Health 9 (5), 456–461. https://doi.org/10.1177/1941738117710938.
Lim, C.W., Tay, G.X., 2015. Kinesio taping in musculoskeletal pain and disability that lasts for more than 4 weeks: is it time to peel off the tape and throw it out with the sweat? A systematic review with meta-analysis focused on pain and also methods of tape application. Br. J. Sports Med. 49, 1558–1566. https://doi.org/10.1136/bjsports-2014-094151.
Lee, H., 2004. The effect of patella taping on quadriceps strength and functional performance in normal subjects. Phys. Therapy Sport 5, 33–36. https://doi.org/10.1016/j.ptsp.2003.09.002.
Lockie, R.G., Schultz, A.B., Callaghan, S.J., Jordan, C.A., Luczo, T.M., Jeffriess, M.D., 2015. A preliminary investigation into the relationship between functional movement screen scores and athletic physical performance in female team sport athletes. Biol. Sport 32 (1), 41–51. https://doi.org/10.5604/20831862.1127281.
Lee, S.M., Lee, J.H., 2017. The immediate effects of ankle balance taping with kinesiology tape on ankle active range of motion and performance in the Balance Error Scoring System. Phys. Therapy Sport 25, 99–105. https://doi.org/10.1016/j.ptsp.2016.08.013.
Montalvo, A.M., Cara, E.L., Myer, G.D., 2015. Effect of Kinesiology taping on pain in individuals with musculoskeletal injuries: systematic review and meta-analysis. Phys. Sports Med. 42 (2), 48–57. https://doi.org/10.3810/psm.2014.05.2057.
McLaren, C., Colman, Z., Rix, A., Sullohern, C., 2016. The effectiveness of scapular taping on pain and function in people with subacromial impingement syndrome: a systematic review. Int. Musculoskelet. Med. 38, 81–89. https://doi.org/10.1080/17536146.2016.1252550.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 6 (7). https://doi.org/10.1371/journal.pmed.1000097.
Moiler, K., Hall, T., Robinson, K., 2006. The role of fibular tape in the prevention of ankle injury in basketball: a pilot study. J. Orthop. Sports Phys. Ther. 36 (9), 661–668 https://www.doi.org/10.2519/jospt.2006.2259.
Mostafavifar, M., Wertz, J., Borchers, J., 2012. A systematic review of the effectiveness of kinesio taping for musculoskeletal injury. Phys. Sports Med. 40 (4), 33–40. https://doi.org/10.3810/psm.2012.11.1986.
Momtazfar, P., Ghazalian, F., Nikbakht, H., 2015. Effect of kinesio taping on hand muscles strength of Karatekaman man. Sport Sci. Health 11, 257–261. https://doi.org/10.1007/s11332-015-0231-3.
McNamara, P., 2016. Cristiano Ronaldo wears Kinesio tape as he steps up recovery by returning to training with Real Madrid. Daily Mail Online. <https://www.dailymail.co.uk/sport/football/article-3750260/Cristiano-Ronaldo-training-Real-Madrid-Zinedine-Zidane-s-men-prepare-La-Liga-opener.html>.
Nelson, N.L., 2016. Kinesio taping for chronic low back pain: a systematic review. J. Bodywork Move. Therap. 20, 672–681. https://doi.org/10.1016/j.jbmt.2016.04.018.
Ozmen, T., Aydogmus, M., Dogan, H., Acar, D., Zoroglu, T., Willems, M., 2016. The effect of Kinesio taping on muscle pain, sprint performance, and flexibility in recovery from squat exercise in young adult women. J. Sport Rehabil. 25, 7–12. https://doi.org/10.1123/jsr.2014-0243.
Oliveria, K.A., borges, D.T., Lins, A.A., Cavalcanti, R.L., Macedo, L.B., Brasileiro, J.S., 2016. Immediate effects of Kinesio Taping on neuromuscular performance of quadriceps and balance in individuals submitted to anterior cruciate ligament reconstruction: a randomized clinical trial. J. Sci. Med. Sport 19, 2–6. https://doi.org/10.1016/j.jsams.2014.12.002.
Pollakoff, B., 2015. Does kinesiology tape work? James Harden, Rockets' trainer believe that it does. NBC Sports. <https://nba.nbcsports.com/2015/04/07/does-kinesiology-tape- work-james-harden-rockets-trainer-believe-that-it-does>.
Peterson, L., Renstrom, P., 2017. Braces and taping used in sport. In: Sports Injuries: Prevention, Treatment and Rehabilitation. CRC Press, United States, pp. 61–63.
Pysny, L., Pysna, J., Petru, D., 2015. Kinesio taping use in prevention of sports injuries during teaching of physical education and sport. Proc. – Soc. Behav. Sci. 186, 618–623. https://doi.org/10.1016/j.sbspro.2015.04.039.
Parreira, P.C.S., Costa, L.C.M., Hespanhol-Junior, L.C., Lopes, A.D., Costa, L.O.P., 2014. Current evidence does not support the use of Kinesio Taping in clinical practice: a systematic review. J. Physiother. 60, 31–39. https://doi.org/10.1016/j.jphys.2013.12.008.
Quirke, M., Harrison, A.J., 2002. The effect of ankle joint taping on the motion of the ankle joint during treadmill running. Proc. Int. Symp. Biomech. Sports 20, 602–604.
Reneker, J.C., Latham, L., McGlawn, R., Reneker, M.R., 2017. Effectiveness of kinesiology tape on sports performance abilities in athletes: a systematic review. Phys. Therapy Sport 31, 83–98. https://doi.org/10.1016/j.ptsp.2017.10.001.
Ram, S., 2016. Why Was Dato' Lee Chong Wei Wearing That Brown Tape On His Shoulders. Says. <https://says.com/my/tech/what-s-the-deal-wit-the-brown-tape-patch-on-lee- chong-wei-and-lin-dan-s-shoulders>.
Sanioglu, A., Ergun, S., Erkmen, N., Taskin, H., Goktepe, A.S., Kaplan, T., 2009. The effect of ankle taping on isokinetic strength and vertical jumping performance in elite taekwondo athletes. Isokinet. Exerc. Sci. 17, 73–78. https://doi.org/10.3233/IES-2009-0336.
Swann, C., Moran, A., Piggott, D., 2015. Defining elite athletes: issues in the study of expert performance in sport psychology. Psychol. Sport Exerc. 16, 3–14. https://doi.org/10.1016/j.psychsport.2014.07.004.
Sekulic, D., Spasic, M., Mirkov, D., Cavar, M., Sattler, T., 2013. Gender-specific influences of balance, speed, and power on agility performance. J. Strength Condit. Res. 27 (3), 802–811. https://doi.org/10.1519/JSC.0b013e31825c2cb0.
Strutzenberger, G., Moore, J., Griffiths, H., Schwameder, H., Irwin, G., 2016. Effects of gluteal kinesio-taping on performance with respect to fatigue in rugby players. Eur. J. Sport Sci. 16 (2), 165–171. https://doi.org/10.1080/17461391.2015.1004372.
Saracoglu, I., Emuk, Y., Taspinar, F., 2018. Does taping in addition to physiotherapy improve the outcomes in subacromial impingement syndrome? A systematic review. Physiother. Theory Pract. 34 (4), 251–263. https://doi.org/10.1080/09593985.2017.1400138.
Serrano, J., Shahidian, S., Sampaio, J., Leite, N., 2013. The importance of sports performance factors and training contents from the perspective of Futsal coaches. J. Human Kinet. 38, 151–160. https://doi.org/10.2478/hukin-2013-0055.
Someeh, M., Norasteh, A.A., Daneshmandi, H., Asadi, A., 2015. Immediate effects of Mulligan's fibular repositioning taping on postural control in athletes with and without chronic ankle instability. Phys. Therapy Sport 16, 135–139. https://doi.org/10.1016/j.ptsp.2014.08.003.
Someeh, M., Norasteh, A.A., Daneshmandi, H., Asadi, A., 2015. Influence of mulligan ankle taping on functional performance tests in healthy athletes and athletes with chronic ankle instability. Int. J. Athletic Therapy Train. 20 (1), 39–45. https://doi.org/10.1123/ijatt.2014-0050.
Salzberg, S., 2014. Did Magic Tape Help Li Na Win The Australian Open. Forbes. <https://www.forbes.com/sites/stevensalzberg/2014/01/26/whats-that-magic-tape- that-pro-athletes-are-wearing/#5fa19dcf3b37>.
Schiffer, T., Mollinger, A., Sperlich, B., Memmert, D., 2015. Kinesio taping and jump performance in elite female track and field athletes. J. Sport Rehabil. 24, 47–50. https://doi.org/10.1123/jsr.2013-0111.
Trecroci, A., Formenti, D., Rossi, A., Esposito, F., Alberti, G., 2017. Acute effects of kinesio taping on a 6 s maximal cycling sprint performance. Res. Sports Med. 25 (1), 48–57. https://doi.org/10.1080/15438627.2016.1258644.
Verhagen, A.P., Vet, H.C., Bie, R.A., Kessels, A.G., Boers, M., Bouter, L.M., Knipschild, P. G., 1998. The Delphi list: a criteria list for quality assessment of randomized clinical trials for conducting systematic reviews developed by Delphi consensus. J. Clin. Epidemiol. 51 (12), 1235–1241.
Vanti, C., Bertozzi, L., Gardenghi, I., Turoni, F., Guccione, A.A., Pillastrini, P., 2015. Effect of taping on spinal pain and disability: systematic review and meta-analysis of randomized trials. Phys. Ther. 95 (4), 493–506. https://doi.org/10.2522/ptj.20130619.
Vitale, J.A., Vitale, N.D., Cavaleri, L., Dazzan, E., Lombardi, G., Mascagni, P., Torre, A.L., Banfi, G., 2018. Level- and sport-specific Star Excursion Balance Test performance in female volleyball players. J. Sports Med. Phys. Fitness. https://doi.org/10.23736/S0022-4707.18.08691-7.

Vercelli, S., Sartorio, F., Foti, C., Colletto, L., Virton, D., Ronconi, G., Ferriero, G., 2012. Immediate effects of Kinesiotaping on quadriceps muscle strength: a single-blind, placebo-controlled crossover trial. Clin. J. Sport Med. 22 (4), 319–326. https://doi.org/10.1097/JSM.0b013e31824c835d.

Zulfikri, N., Justine, M., 2017. Effects of Kinesio taping on dynamic balance following fatigue: a randomized controlled trial. Phys. Therapy Res. 20 (1), 16–22. https://doi.org/10.1298/ptr.E988.