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Risk factors associated with knee and wrist injuries in Chinese male breakdancers

Lu Bai[1], Huiye Jia[2] and Bo Wang[2]

[1]*School of Art, Beijing Sport University, Beijing, China*
[2]*School of Sport Medicine and Rehabilitation, Beijing Sport University, Beijing, China*

ABSTRACT

This study aimed to identify the potential risk factors associated with knee and wrist injuries in Chinese male breakdancers. A cross-sectional study was conducted from May to August 2023 using a self-administered online questionnaire distributed to 689 male breakdancers with at least two years of training experience. The questionnaire covered demographics, training patterns, injury protection knowledge, and injury characteristics in the preceding 24 months. Among the participants, 621 dancers (90.1%) reported at least one injury, totaling 1,056 injuries. Wrist injuries (247 cases, 23.3%) and knee injuries (205 cases, 19.4%) were the most common injuries. Regression analysis indicated that being a self-identified beginner (OR = 0.176, 95% CI, 0.046–0.681) and performing warm-ups of 10–20 minutes (OR = 0.259, 95% CI, 0.092–0.728) or 20–30 minutes (OR = 0.162, 95% CI, 0.05–0.529) were protective against knee injuries. For wrist injuries, longer training duration (OR = 0.958, 95% CI, 0.921–0.997) was protective, while specialization in footwork (OR = 1.591, 95% CI, 1.078–2.349) and having basic (OR = 1.808, 95% CI, 1.101–3.189) or some knowledge (OR = 1.885, 95% CI, 1.115–3.189) of injury prevention were associated with higher injury risk. Most injuries occurred during training, with fatigue and technical errors as the primary causes. Variables with a univariate association of $P < 0.05$ with the injury outcome were considered eligible for inclusion as covariates in the final multivariate logistic regression models to adjust for potential confounding factors. Longer training duration and adequate warm-up demonstrated protective effects against wrist injuries, underscoring the importance of professional instruction and injury prevention knowledge.

Keywords: male, breakdancer, wrist, knee, injury risk

INTRODUCTION

Breakdance originated in 1973 in the Bronx, USA. It is an unstructured, highly improvised type of dance that emphasizes the expression of personal styles and artistic creation. In the past 2 years, breakdances have gained more public exposure and have become popular among teenagers.[1] Additionally, breakdance officially became a competitive program at the 2024 Paris Olympic Games.[2]

The main technical movements in breakdance include toprock, footwork, freeze, and power-

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Corresponding Author: Bo Wang, PhD
School of Sport Medicine and Rehabilitation, Beijing Sport University,
No. 48, Xinxi St, Haidian District, Beijing 100084, China
Tel: +86 18600242675, E-mail: WangBOphd@outlook.com

move, and its competitive forms are ciphers and battles.[3] Ojofeitimi reported that the technical characteristics and movement patterns of breakdance are similar to gymnastics; hence, they share common injury features, with a high incidence rate concentrated in the upper and lower limbs.[4] During the movement process, the body is in a highly distorted state to complete the support, rotation, flip, and other complex technical movements using different parts of the body, such as the wrists and cervical vertebrae. Arundale reported that the wrist and knee injuries were very common in breakdance, they primarily involving ligament and tendon damage, which is closely related to their technical characteristics.[3] Moreover, to demonstrate their dancing skills in competitions, breakdancers usually incorporate many difficult combinations of movement techniques, substantially increasing the risk of injury.[4] During competitions, breakdancers have to adapt their movements to the live music within a 45-second performance. Breakdance, as a freestyle form, requires dancers to improvise according to the music, resulting in more randomized movement changes, with some dancers performing technical movements they have never practiced.[5] Compared to other dance forms, breakdance venue selection is more informal and frequently occurs in unstructured settings, such as on cement, marble, and other unconventional surfaces, which further increases the risk of injury to dancers.[4] Therefore, the previous studies revealed the fact that breakdancing injury rate is high, and these studies have indicated that knee and wrist injuries are the predominant categories among all breakdancing-related injuries. However, the risk factors and protective strategies for these specific injuries remain to be further investigated.

This is the first study to focus on the risk factors for male Chinese breakdance-associated injuries and their protection strategies especially for wrist and knee injuries. Base on previous studies, we hypothesized that the longer training duration, dancing skill levels, high-difficulty technical movement and inadequate training were the main risk factors for the breaking dancers. Therefore, this study aimed to investigate the training patterns and injury characteristics among Chinese male breakdancers using a retrospective survey of injury profiles. Furthermore, we specifically assessed knee and wrist injuries and identified their risk factors, thereby providing scientific support for injury prevention strategies in breakdance.

MATERIALS AND METHODS

Research methods

This cross-sectional study used a self-administered questionnaire to survey breakdancers regarding injuries. The investigative period was extended to the past 24 months to include more types of injuries.[6] It is important to note that this design inherently cannot establish causal relationships between the variables examined due to the simultaneous measurement of exposure and outcome. Furthermore, reliance on self-reported data introduces the potential for recall bias. These limitations are acknowledged as integral to the methodological framework.

The study was designed in January 2023, and risk factor assessment was conducted to analyze the causes and mechanisms of injuries from May 2023 to August 2023. The data analysis was completed in October 2023. This study adhered to Declaration of Helsinki and was approved by Ethics Committee of Beijing Sport University (project no. 2024152H). All participants provided informed consent, and their responses were anonymized. Consent for publication was obtained from the participants or their guardians. This study started in March 2023, and the data analysis started in June 2023. The study adheres to the relevant guidelines for reporting research and followed Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement to ensure the rigor and transparency of our study design, analysis, and reporting.

Study participation

This study investigated male breakdancers who engaged in regular weekly training. The inclusion criteria were as follows: 1) age ≥ 18 years; 2) no cognitive impairment and ability to understand and independently complete the questionnaire; 3) voluntary participation in the study after understanding its purpose and process, including completing the informed consent form; and 4) at least 24 months of breakdance training experience. The exclusion criteria included: 1) less than 24 months of breakdance training; 2) primarily engaged in other forms of street dance other than breakdance; 3) stopped breakdance training for more than 6 months; 4) training duration of less than 3 hours per week; and 5) unable to continue breakdancing due to musculoskeletal or joint injuries/conditions (Table 1).

Table 1 Basic information of participants

Basic information	Mean ± SD
Number (N)	689
Age (y)	24 ± 6.10
Hight (cm)	170.9 ± 8.80
Weight (kg)	64.2 ± 10.90
BMI (kg/m^2)	21.9 ± 3.00

BMI: body mass index

Development and distribution of the questionnaire

The questionnaire was a self-designed tool developed in consultation with experts in breakdance, sports medicine, and sports rehabilitation using the Delphi method. This method determines the positive coefficient of expert consensus and the degree of concentration and coordination among expert opinions, as well as the validity of the questionnaire. The key statistical measures used for the analyses included coefficient of variation (Cv), Kendall's coefficient of concordance (Kendall's W, W), and other indicators. The degree of expert authority (Ca) was determined using the formula: Ca = (Ci + Cs)/2, where Ci is the basis of judgment and Cs is the familiarity with the research content. The degree of expert coordination was tested by the non-parametric Kendall's W coordination coefficient, with statistical significance set at $P < 0.05$. The questionnaire was tested using the within-group correlation coefficients (intraclass correlation coefficient [ICC], Cv, and Kendall's W, W). ICC was used to assess the re-test reliability of the questionnaire. A Cv < 0.5 and a Kendall's W coefficient < 0.5 were established as the statistical thresholds for expert consensus in this study. The results showed Cv < 0.5, the judgment was based on Ci = 0.82, the degree of expert authority Ca = 0.84, indicating a high degree of expertise, and the expert coordination coefficient W between 0.4–0.5, indicating an acceptable degree of coordination of the experts in this study; the re-test reliability was good (ICC = 0.84). As Injury Incidence in Hip Hop Dance described "breakdance-related injury was strictly defined as any musculoskeletal condition: (1) that was formally diagnosed by a qualified medical professional using standardized clinical criteria, (2) occurred during breakdance activities within the past 24 months, and (3) resulted in either medical treatment requirement or time-loss from normal training/activities for at least 24 hours."

The questionnaire consisted of three sections with a total of 28 questions. Part 1 contained four questions on basic information: age, height, weight, and dominant hand. Part 2 consisted

of 14 questions on breakdance training and injury protection: breakdance training years, training sessions per week and the time spent on each training session, the warm-up time before each training, the stretching time after each training, the self-identified rank of breakdance, participation in competitions, the presence of a breakdance instructor during the training, exercise protection condition, knowledge of injury prevention and treatment, knowledge of sports protection measures, access to medical support, specialization in breakdance skills, involvement in other dance forms, physical and fitness training condition, and the degree of risk-taking behaviors. Part 3 contained 10 questions related to the characteristics of breakdance injuries, including whether an injury occurred in the previous 24 months, the type and location of injuries, the environment where injuries occurred, movements associated with the injuries, and their causes (Supplementary Figure). Hence there is no official skill classification when the research started, the classification of breakdancers' skill based on previous studies,[7,8] this study defined breaking skill levels through the dancers' self-assessment. The questionnaire was distributed with online platforms to breakdance training institutions, clubs, and individual dancers. The research team completed the questionnaire on the WJX app (a platform providing functions equivalent to Amazon Mechanical Turk. RanXing Corp, Hu Nan, China) and distributed to breakdancers by WeChat app (Tencent Corp, Guang Dong, China). The survey was ultimately distributed to approximately 1300 potential participants.

Statistical methods

All statistical analyses were conducted using Excel (Microsoft Corp, Redmond, WA, USA) and SPSS version 22.0 (IBM Corp, Armonk, NY, USA). T-tests were applied to parametric data (including height and weight, age, and body mass index [BMI]), and Mann-Whitney *U* tests were applied to non-parametric and non-normally distributed data (including years of training, training frequency, and training time). Logistic regression analysis was performed to examine the potential associations between various factors and injuries. Multicollinearity was assessed by calculating variance inflation factor (VIF) for each independent variable within a linear regression framework in SPSS. All variables had VIF values below 5, indicating that multicollinearity was not a critical concern in the model. Factors with $P < 0.05$ were used as adjustment factors for potential confounders and were included in the multivariate logistic regression model. The results are presented as unadjusted (crude), adjusted odds ratios (OR), and 95% confidence intervals (CI). A two-tailed $P < 0.05$ was considered statistically significant.

RESULTS

Basic participant information

A total of 1095 questionnaires received and 689 valid questionnaires (male breakdancers) were finally participated in this study, with a age of 24 ± 6.1 years. The mean height was 170.9 ± 8.8 cm, mean weight was 64.2 ± 10.9 kg, and mean BMI was 21.9 ± 3 kg/m^2 (Table 1).

Basic training information

Among 689 breakdancers, the average training duration is 8.3 ± 4.5 years. The self-reported skill levels were distributed as follows: 57.5% basic, 23.7% advanced, and 13.2% professional. Participants trained 4.13 times weekly (2.8 ± 1.4 hours per session), with 57.6% warm-up 5–10 minutes while 42.2% omitted post-training cool-down. Competition participation was high (92.4%); however, 60.8% lacked professional instruction, and 84.5% had no medical support. Technical specialties included footwork (60.5%), toprock (43.1%), freezes (39.2%), and power-move (36.4%). Regarding injury prevention, 19.9% had no knowledge while 60.4% acquired it

during training. Physical training engagement showed 51.7% performing strength training, though 29.6% reported no specific training and 27.8% dedicated 30–60 minutes weekly to physical conditioning (Table 2).

Table 2 Breakdancer training and injury protection status

		Mean ± SD	Number (n)	Percentage (%)
Dominant hand	Right		605	87.8
	Left		84	12.1
Dancing time (y)		8.3 ± 3.5		
Training time (per week)		4.13 ± 2.01		
Training time (h/each time)		2.8 ± 1.4		
Warm-up time (min)	None		51	7.4
	5–10		397	57.6
	10–20		159	23.1
	20–30		62	9.0
	Over 30		20	2.9
Stretching time (min)	None		291	42.2
	5–10		305	44.3
	10–20		67	9.7
	20–30		17	2.5
	Over 30		9	1.3
Self-identified breakdance rank	Beginner		39	5.7
	Basic		396	57.5
	Advanced		163	23.7
	Professional		91	13.2
Competition participation	Yes		637	92.4
	No		52	7.6
Breakdance instructors	Yes		270	39.2
	No		419	60.8
Medical support	Yes		107	15.5
	No		582	84.5
Specialized skill	Toprock		297	43.1
	Footwork		417	60.5
	Freeze		270	39.2
	Powermove		251	36.4
Knowledge of sports injury protection	None		137	19.9
	A little		294	42.7
	Partially understand		200	29.0
	Very much		58	8.4

Physical or fitness training	None	204	29.61
	Strength	356	51.67
	Cardiovascular	51	7.40
	Flexibility	31	4.5
	Coordination or agility	47	6.8
Physical or fitness training time (per week)	<0.5 hour	114	23.5
	0.5–1 hour	135	27.8
	1–2 hours	109	22.5
	3–4 hours	70	14.4
	4–5 hours	21	4.3
	Over 5 hours	36	7.4

Injury status

Over the previous 24 months, 621 dancers (90.1%) reported at least one breakdance-related injury. The total number of reported injury cases was 1056 (1.7 injuries per dancer on average), with wrist injuries (247 cases, 23.3%) and knee injuries (205 cases, 19.4%) having the highest incidence rates (Table 3).

Table 3 Incidence injury of breakdancers' body part

Injury part	Case number (n)	Percentage (%)
Wrist	247	23.3
Knee	205	19.4
Shoulder	139	13.1
Low back	131	12.4
Neck	74	7.0
Ankle	63	5.9
Finger	56	5.3
Elbow	42	3.9
Feet/Toes	38	3.5
Back	26	2.4
Head	18	1.7
Pelvic	17	1.6

Comparison of risk factors for wrist and knee injuries

Wrist and knee injuries ranked first and second among all injuries, respectively (Table 3), and the risk factors associated with these injuries were determined. Comparisons were made between the knee injury and non-injury groups, as well as between the wrist injury and non-injury groups. In the knee injury group, significant differences in breakdance rank, competition participation, and medical support were observed between the injury and non-injury groups. In

the wrist injury group, significant difference was observed in the breakdance practice time and primary technique (Tables 4, 5, and 6).

Table 4 Comparison of risk factors between knee and wrist injured and non–injured individuals

	Knee			Wrist		
Risk factor	Non–injury (n = 481)	Injury (n = 175)	*P*	Non–injury (n = 440)	Injury (n = 216)	*P*
Dominate hand			0.151			0.132
Left	62 (12.9%)	18 (10.3%)		48 (10.9%)	32 (14.8%)	
Right	419 (87.1%)	157 (89.7%)		392 (89.1%)	184 (85.2%)	
Knowledge of sports injury protection			0.93			0.053
Very much	40 (8.3%)	13 (7.4%)		35 (8%)	18 (8.3%)	
Partly understand	142 (29.5%)	54 (30.9%)		127 (28.7%)	69 (31.9%)	
A little	207 (43%)	72 (41.1%)		179 (40.7%)	100 (46.3%)	
None	92 (19.1%)	36 (20.6%)		99 (22.5%)	29 (13.4%)	
Warm-up time (min)			**0.024***			0.086
None	32 (6.7%)	15 (8.6%)		34 (7.7%)	13 (6%)	
5–10	276 (57.4%)	10 (58.9%)		268 (60.9%)	111 (51.4%)	
10–20	115 (23.9%)[#]	37 (21.1%)[#]		92 (20.9%)	60 (27.8%)	
20–30	48 (10%)[#]	11 (6.3%)[#]		35 (8%)	24 (11.1%)	
>30	10 (2.1%)	9 (5.1%)		11 (2.5%)	8 (3.7%)	
Self-identified breakdance rank			**<0.01****			0.408
Beginner	28 (5.8%)[#]	3 (1.7%)[#]		23 (5.2%)	8 (3.7%)	
Basic	275 (57.2%)	99 (56.6%)		256 (58.2%)	118 (54.6%)	
Advanced	118 (24.5%)	42 (24%)		106 (24.1%)	54 (25%)	
Professional	60 (12.5%)[#]	31 (17.7%)[#]		55 (12.5%)	36 (16.7%)	
Competition participation			**0.043***			0.404
Yes	443 (92.1%)	169 (96.6%)		413 (93.9%)	199 (92.1%)	
No	38 (7.9%)[#]	6 (3.4%)[#]		27 (6.1%)	17 (7.9%)	
Breakdance instructor			0.796			0.124
Yes	184 (38.3%)	65 (37.1%)		176 (40%)	73 (33.8%)	
No	297 (61.7%)	110 (62.9%)		264 (60%)	143 (66.2%)	
Medical support			0.05			0.248
Yes	79 (16.4%)	18 (10.3%)		70 (15.9%)	27 (12.5%)	
No	402 (83.6%)	157 (89.7%)		370 (84.1%)	189 (87.5%)	
Specialized skill			0.131			**0.009****
Footwork	278 (59.8%)[#]	118 (69%)[#]		287 (67.4%)[#]	110 (52.1%)[#]	
Freeze	186 (40%)	74 (74%)		167 (39.2%)	93 (44.1%)	
Powermove	188 (40.4%)	55 (32.2%)		149 (35%)[#]	94 (44.5%)[#]	
Toprock	112 (23.2%)	47 (26.7%)		121 (27.5%)	46 (21.3%)	

Risk behavior			0.152			0.927
High	124 (29.5%)	51 (29.1%)		113 (29.7%)	65 (30.1%)	
Moderate	247 (58.7%)	93 (53.1%)		218 (57.4%)	121 (56%)	
Low	50 (11.9%)	31 (17.7%)		49 (12.9%)	30 (13.9%)	
Physical or fitness training			0.557			0.95
Yes	345 (71.7%)	120 (69%)		312 (71.1%)	153 (70.8%)	
No	136 (28.3%)	53 (31%)		127 (28.9%)	63 (29.2%)	
Physical or fitness training (per week)			0.550			0.283
None	36 (28.3%)	54 (31%)		127 (28.9%)	63 (29.2%)	
0.5	81 (16.8%)	29 (16.7%)		64 (14.6%)	46 (21.3%)	
0.5–1	95 (19.8%)	31 (17.8%)		90 (20.5%)	36 (16.7%)	
1–2	78 (16.2%)	28 (16.1%)		73 (16.6%)	33 (15.3%)	
3–4	53 (11%)	16 (9.2%)		44 (10%)	25 (11.6%)	
4–5	11 (2.5%)	9 (5.2%)		16 (3.6%)	5 (2.3%)	
>5	26 (5.4%)	7 (4%)		25 (5.7%)	8 (3.7%)	

*$P < 0.05$ indicates that there is significant difference between the non-injured and injured groups, **$P < 0.01$ indicates that there is highly significant difference between the non-injured and injured groups. # indicates that there is some significant difference within each subgroup.

Table 5 Comparison of training situation between knee and wrist injured and non-injured individual (median (interquartile range))

	Knee				Wrist			
Training situation	Non-injury (n = 481)	Injury (n = 175)	*P*	*r*	Non-injury (n = 440)	Injury (n = 216)	*P*	*r*
Dancing time (y)	8.0 (6.0)	8.0 (7.0)	0.236	0.05	8.0 (7.0)	8.0 (5.0)	0.021*	0.09
Training time (n/per week)	4.0 (2.5)	4.0 (2.0)	0.868	<0.01	4.00 (2.00)	4.0 (3.0)	0.286	0.04
Training time (h/each time)	2.5 (1.0)	3.0 (1.0)	0.652	<0.02	2.50 (1.00)	3.0 (1.0)	0.987	<0.01

*$P < 0.05$ indicates that there is significant difference between the non-injured and injured groups

Table 6 Comparison of training situation between knee and wrist injured and non-injured individuals (mean)

	Knee			Wrist		
Training situation	Non-injury (n = 481)	Injury (n = 175)	*P*	Non-injury (n = 440)	Injury (n = 216)	*P*
Age (y)	24 (21–28)	25 (21–30)	0.285	25 (21–29.8)	24 (21–27.8)	0.065
BMI (kg/m^2)	21.8 (20.5–23.6)	21.6 (20.5–23.8)	0.792	21.8 (20.4–23.7)	21.8 (20.5–23.6)	0.932

BMI: body mass index

Regression analysis of knee and wrist injuries

After regression analysis, seven indicators related to knee injuries in break dancers were identified. These indicators were analyzed using multivariate regression models, and three indicators were included in the regression equation: "self-identified breakdance rank as beginner" (OR = 0.176, 95% Cl, 0.046–0.681), which indicated a lower injury risk level. The "warm-up duration between 10–20 minutes" (OR = 0.259, 95% Cl, 0.092–0.728), and "warm-up duration between 20–30 minutes" (OR = 0.162, 95% Cl, 0.05–0.529) indicate the lower injury risk level (Supplementary Table 1). Eight indicators were associated with wrist injuries in breakdancers. These indicators were analyzed using a multifactorial regression model, and four indicators were finally included in the regression equation: "breakdance time" (OR = 0.958, 95% CI, 0.921–0.997) indicated a lower injury risk level. A higher injury risk was associated with "specialized skill in footwork" (OR = 1.591, 95% CI, 1.078–2.349), "knowledge of injury prevention" (OR = 1.885, 95% CI, 1.115–3.189), and "basic knowledge of injury prevention" (OR = 1.808, 95% CI, 1.101–2.972) (Supplementary Table 2).

Univariate comparison of risk factors between knee injury and wrist injury groups

Univariate comparisons were conducted between the knee and wrist injury groups regarding injury conditions after sustaining the injury. The results revealed significant differences between the two groups in terms of injury environment, injury movement, cause of injury, type of injury, nature of damage, and self-assessed reason for injury ($P < 0.01$) (Supplementary Table 3).

DISCUSSION

Injury rate among Chinese male breakdancers

Breakdance injury rate among Chinese male breakdancers was over 90% within 24 months, similar to that in other studies.[9,10] In a study of 232 street dancers with up to 6 months of injury tracking, Ojofeitimi et al[4] reported that breakdancers had an annual injury incidence of 278%, with an average of 3.5 injuries per athlete per year. This is twice as high as the incidence observed in other dance styles, including New School dance styles, such as locking and popping.[11] The annual injury rate in breakdance is 3–4 times higher than that in modern dance, twice as high as that in taps, and eight times higher than that in ballets.[4]

Injury characteristics among Chinese male breakdancers

Basic breakdance movements involve support and rotation using various body parts, significantly increasing the risk of injury to different joints. In our study, wrist and knee injury rates were the highest. Wrist injuries were reported in 247 cases and knee injuries in 205 cases, accounting for 23.3% and 19.4% of the total number of cases, respectively. This result is consistent with those of previous studies.[12-15]

Most injuries occurred during training. This may be attributed to the fact that dancers spend much more time training than competitions, substantially increasing their exposure to injury risk. Rodrigues[16] pointed out if the soccer player training frequency above 5 days a week, the overtraining and injury risk significantly increased. Tjukov et al[14] demonstrated that the probability of injuries in breakdancers' training was higher, with 59.3% of injuries occurring during training and 25.9% of injuries occurring in competitions. The effective trainer supervision and medical support can reduce the incidence of injuries during training.[17]

The instructor may effectively supervise the dancers' training process, thereby ensuring that the intensity and technical difficulty of the training increase progressively.[18] This allows the dancers to

establish a solid fundamental skill before performing more challenging and difficult movements. Moreover, the instructors can provide dancers with comprehensive guidance on warm-up and stretching routines, including their timing, techniques, as well as proper activation and relaxation methods, thereby reducing the incidence of injuries caused by difficult skills.[5,11] However, in our study, only 39.2% of the dancers had a breakdance instructor, and 15.8% had medical support during training. Therefore situation may associated with the fact that many breakdancers attempt more difficult techniques during training when they have not yet fully mastered the fundamental skill. They often choose the training location randomly, such as outdoors or on other hard surfaces, which makes training more likely to be associated with injuries. Their results also revealed a higher incidence of knee and wrist injuries during training.

Fatigue is the main self-assessment injury reason among all dancers. Ojofeitimi et al[4] and Tjukov et al[14] noted that many breakdancers believed that their injuries were due to overuse and fatigue. Effective training instruction and supervision lower the risk of injury by reducing fatigue and setting appropriate training plans.[19,20] Moreover, the comprehensive injury prevention education can significantly reduce the incidence of sports-related injuries.[21,22] However, only 39.2% of dancers had instructors to supervise their training, which may be associated with the low warm-up and stretching-relaxation rate, overuse, and fatigue in dancers. A possible reason for this situation is that when breakdancing first gained popularity in China, there was very few of institutional instructors, and many dancers were self-taught through online videos.

Difference of risk factors between wrist and knee injuries

Notably, the results revealed that distinct skill types were associated with knee and wrist injuries. Knee injuries were mostly associated with footwork and falling (33.7%). Footwork is a skill heavily dependent on knee joint movement, requiring the knee joint to support body weight and finish a wide range of knee flexion and extension movements in an unstable position. Previous studies have shown that knee flexion at greater angles increases the risk of meniscal injury by 13%.[23] In this study, approximately 23% of knee injuries were sprains, whereas 27.3% were related to intra-articular and peripheral tissues, and these injuries were strongly linked to excessive knee flexion, extension and twisting movements. They represent different technical factors that contribute to wrist and knee injuries.

Powermove was the most predominant skill type that led to wrist injuries, with a 69.9% injury rate, which is consistent with that of previous research.[24] Dancers rely on their arms to support their entire body weight, which induces pressure on the wrist, causes injury. Many movements rely on upper-body support, in particular, the powermove skills involve using the arms to support the entire body weight to accomplish different stabilization and rotation movements, including airflare, 2000, and airchair (Figure 1, Competition Rules, 2024-03-22, http://www.worlddancesport.org/Rule/Competition/General). Movements such as 2000, headspin, drill, and handglide involve spinning around one axis of rotation, whereas airflare and windmill involve both spinning and metric rotations.[25] The wrist joint must withstand high twisting and impact forces, which require dancers to have sufficient strength and neuromuscular ability to control wrist stability.[25]

Although footwork is a lower-limb skill, the wrist joint is involved in the weight-bearing support process with a certain amount of twisting motions. Many dancers prioritize lower limb training but neglect upper limb training, especially basic wrist-specific exercises. This imbalance may explain the higher risk of wrist injuries among footwork movements. Notably, a high percentage of wrist injuries were tenosynovitis, owing to the half-palm and fingertip support during footwork, resulting in extreme loading of the wrist flexor and extensor tendons and the thumb tendon.[26] This may explain why wrist sprains are primarily caused by sprains (44%). Therefore, the dancers faced significant risks when practicing techniques movement before they mastered it.

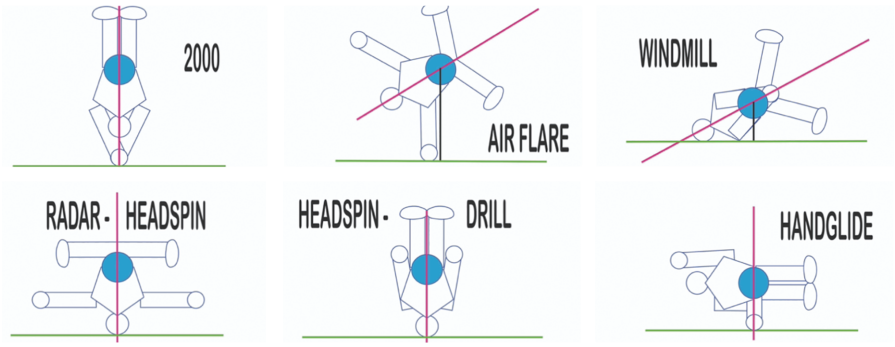

Fig. 1 Powermove combinations

Each of the six images shows several common rotation techniques in breakdance powermove skills. The red line indicates the axis of rotation. Among these techniques, 2000, headspin, drill, and handglide involve spinning around one axis of rotation, whereas the airflare and windmill involve both spinning and metric rotation. 2000 (Swirls): A 360-degree body rotation performed while suspending the body with both hands. Airflare: A circular body rotation propelled by alternating one-handed supports. Windmill: A continuous rotation where the body moves in a circular path, supported by the upper back and shoulders. Headspin Radar/Drill: A rotation on the head, which can be performed either stationary or in a 360-degree spin. Handglide: A body rotation balanced on one hand.

To minimize the risk, dancers should establish good fitness and fundamental skills before starting powermove training. Instructors should carefully monitor training, including the training location, protective gear, warm-up and stretching sessions, and other protective measures. Yu[27] determined that the best warm-up is a multi-stage routine that focuses on dynamic stretches and adds a few short bursts of high-intensity moves. Avoid holding long static stretches before the main workout or competitions. In addition to training monitors, health education for breakdancers is crucial for injury prevention during training. Our study findings showed that less than 40% of dancers had adequate knowledge of injury protection, and only 8.4% had high injury-related knowledge levels. Despite the dancers who had a few protection knowledge were susceptible to injury, a plausible explanation is due to a situation that dancers who got injured sought out more knowledge after injury. In the previous study, Joka pointed out the adequate injury protection education is very important for the breaking dancers,[28] lack of sports injury prevention knowledge has a detrimental effect on injury protection.[29] Therefore, educating dancers and training monitors on sports injury prevention is an important task for the future.

Protective factors for wrist and knee injuries in male breakdancers

A longer training duration had a protective effect against wrist injuries in breakdancers. This finding is contrary to previous studies.[28] A longer training exposure increases the injury risk; however, the mastery of technical skills also requires a substantial amount of time for training. Meanwhile, powermove movement specialization is not a significant risk factor for wrist injury. This result may be attributed to the fact that the neuromuscular control of dancers develops over years of training, thereby enhancing their stability and reducing the risk of injuries.[30] Additionally, their body movements become more skilled with years of training, which may be another important factor that provides protection against wrist injury when performing challenging movements involving their upper limbs. Therefore, longer training periods may achieve a protective effect by improving technical skills.

Sufficient warm-up time reduces the risk of knee injuries in breakdancers. Previous studies have revealed that many dancers attribute injuries to inadequate warm-up.[15,31,32] Cho et al[13] found

that 33% of dancers did not warm-up before dancing, and 62% cited a lack of warm-ups as a contributing factor to injuries. The study revealed that 7.4% of the dancers skipped a warm-up routine before dancing, whereas 57.6% warmed up for 5–10 minutes, which is insufficient. The warm-up time should over 20 minutes in the most of exercise.[33] Static stretching or low-intensity aerobic exercise, commonly used by dancers to warm-up before training, is inadequate for the high-intensity demands of breakdance. The high insufficient warm-up rate is related to a low instructing rate,[34] and the dancers should learn the knowledge of warm-up, including the proper timing, activation methods, and correct techniques for both dynamic and static stretching. Therefore, qualified dance instructors and a well-designed warm-up protocol can significantly reduce the risk of injury.

Beginner-level breakdance had a protective effect against knee injuries. Previous studies have shown that athletes with different skill levels have significantly different injury risks.[7,35] Cross-sectional studies by Cho et al[13] and Kauther et al[12] revealed that professional dancers were more susceptible to injuries than amateur dancers owing to longer training periods, higher skill levels, and joint overuse during difficult movements. In the early stages of breakdance training, dancers train for short durations, which reduces the likelihood of overuse injuries. This reduces their injury exposure risk compared to advanced and professional dancers. Additional, Moriarty[36] figured that injury rates are not directly linked to skill level, but are more related to the specific body part injured. However, due to the excessively wide confidence interval, this finding still require further research for verification.

LIMITATIONS

This cross-sectional study had some limitations. First, this study did not conduct the sample size calculation or power analysis. The sample size was primarily determined by the practical considerations of participant accessibility within the study timeframe. Consequently, although the large overall sample provides robust power for detecting moderate-to-large effects, it is possible that the study was underpowered to identify smaller, yet potentially important associations. Second, this study categorized dancers' skill levels based on self-assessment, which may have led to potential inaccuracies. Furthermore, the official validation standard for this classification is absence. Third, owing to the limited population of female breakdancers and low participation rates ($n < 20$), this study only enrolled male breakdancers as participants. Moreover, the study is a 24-month retrospective study, the evidence's reliability is lower than the prospective study, there are likely confounding factors associated with the risk factors for both knee and wrist joint injuries. Additionally, the study used a self-developed questionnaire, which limits comparisons with other studies that used the same methodology. Therefore, future research should focus on injuries affecting female breakdancers and analyze the relationship between injuries and all possible risk factors. During the regression analysis, the lack of completely separate analysis for the two types of injuries may have introduced some inaccuracies in the results. The relationship between injury severity and frequency also warrants further investigation. By employing more robust sample sizes and regression analyses, future research will provide more reliable evidence for injury prevention protocols for Chinese breakdancers.

CONCLUSIONS

This study identified a high injury incidence among breakdancers, with knee and wrist injuries

being predominant during training. These injuries were primarily associated with fatigue and specific techniques—powermove for wrists and footwork for knees. Longer training duration and adequate warm-up demonstrated protective effects against wrist injuries, underscoring the importance of professional instruction and injury prevention knowledge.

RECOMMENDATIONS

To mitigate injury risks in breakdance, it is recommended that instructors systematically monitor training intensity using standardized checklists, while dancers should master fundamental movement patterns before advancing to higher-level skills. Dancers should learn about injury prevention and warm-up before they start training. Future research should quantify joint loads through biomechanical analysis and design randomized controlled trials to validate the efficacy of warm-up regimens.

DECLARATIONS

Authors' contributions

(1) Lu Bai and Bo Wang conceived and designed the study;
(2) Lu Bai and Huiye Jia collected the data;
(3) Lu Bai and Huiye Jia analyzed and interpreted the data;
(4) Lu Bai wrote the manuscript;
(5) Bo Wang provided critical revisions that are important for intellectual content;
(6) Lu Bai, Huiye Jia, and Bo Wang approved the final version of the manuscript.

Conflict of interest

All authors declare that they have no conflict of interest.

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Availability of data and materials

The datasets used and/or analyzed in the current study are available from the corresponding author upon reasonable request.

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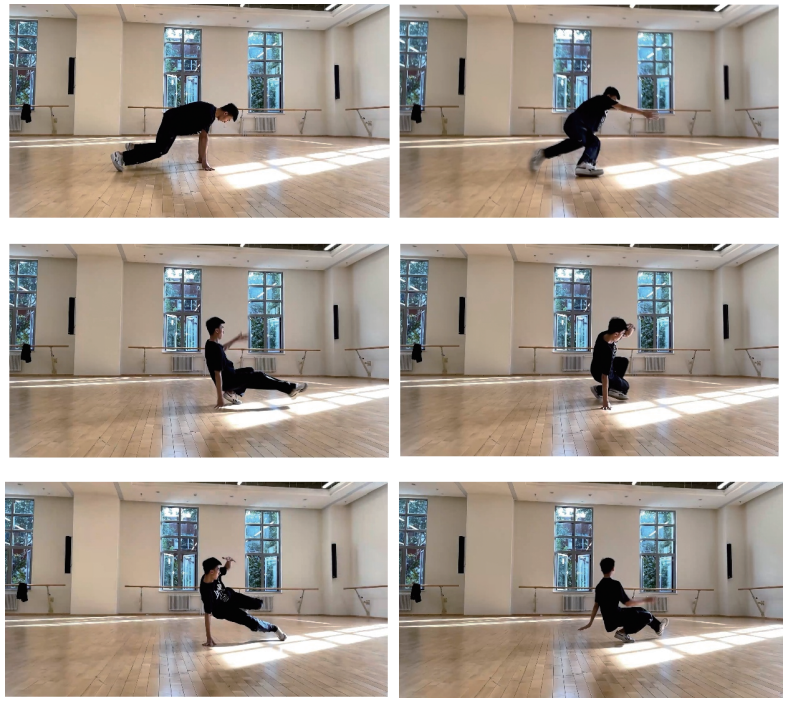
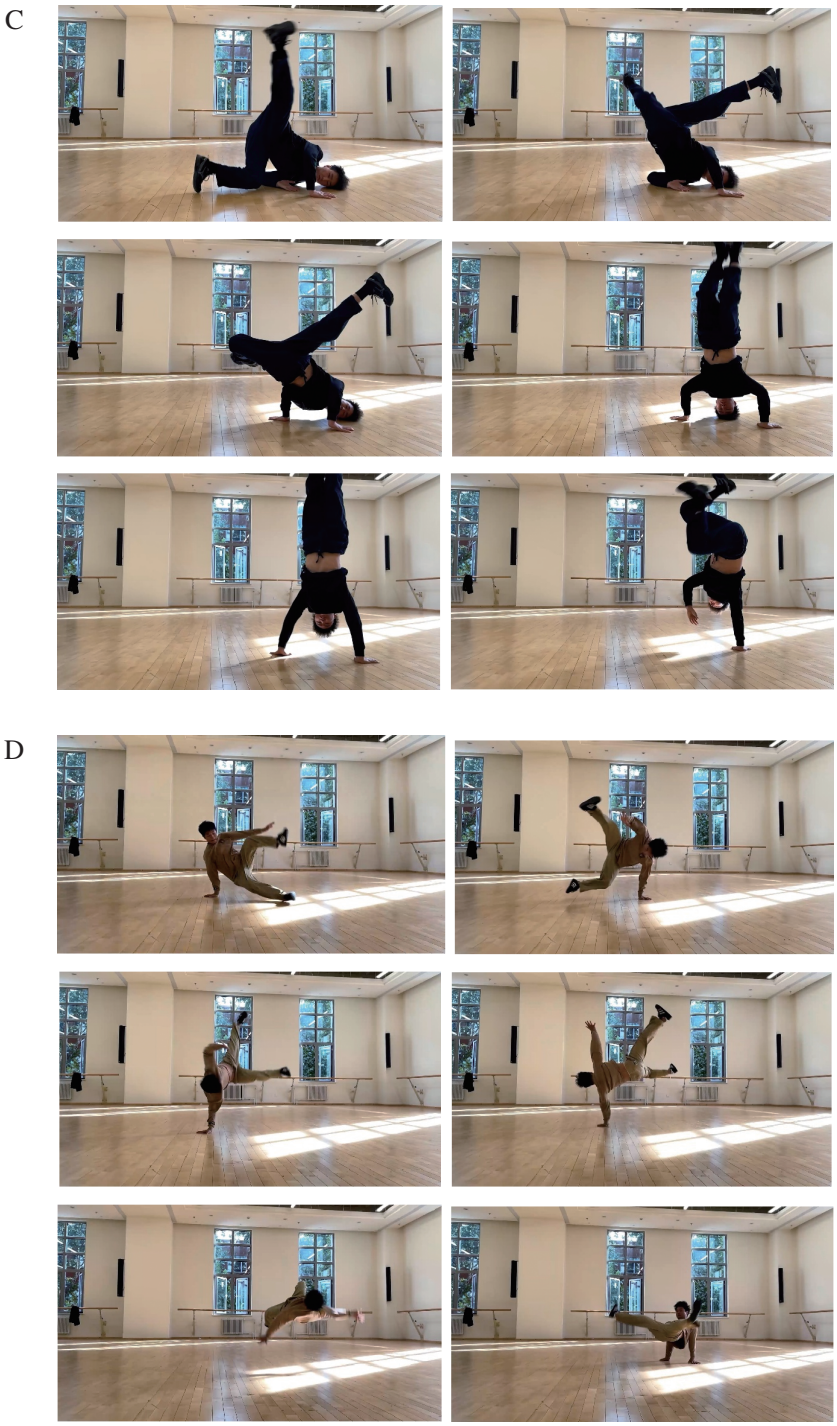
SUPPLEMENTARY INFORMATION

A

B





Supplementary Figure Instruction of breakdance movement
Basic movement of Toprock (A), Footwork (B), Freeze(C), Powermove (D).
All individuals depicted in the photographs in Suppl Figure have provided consent for their images to be published in this paper.

Supplementary Table 1 Univariate and multivariate analysis results of knee injuries

Risk factor		Crude odds ratio		Adjusted odds ratio	
		OR (95% CL)	*P*	OR (95% CL)	*P*
Dominate hand		1.291 (0.74–2.25)	0.368		
Dancing time		1.036 (0.997–1.077)	0.069		
Competition participation		0.414 (0.172–0.997)	**0.049***	1.896 (0.736–4.886)	0.185
Self-identified breakdance rank	Beginner	0.207 (0.058–0.736)	**0.015***	0.176 (0.046–0.681)	**0.012***
	Basic	0.697 (0.427–1.138)	0.149		
	Advanced	0.689 (0.394–1.204)	0.191		
	Professional				
Medical Support		1.714 (0.995–2.953)	0.052		
Specialized skill	Footwork	1.552 (1.077–2.236)	**0.018***	0.688 (0.466–1.017)	0.061
	Freeze	1.162 (0.818–1.652)	0.403		
	Toprock	0.855 (0.427–1.251)	0.384		
	Powermove	0.714 (0.494–1.032)	0.073		
Warm-up time	None	0.521 (0.175–1.548)	0.241		
	5–10 min	0.415 (0.164–1.049)	0.063		
	10–20 min	0.357 (0.135–0.947)	**0.038***	0.259 (0.092–0.728)	**0.01***
	20–30 min	0.255 (0.084–0.775)	**0.016***	0.162 (0.05–0.529)	**0.003****

*$P < 0.05$ indicates a statistical significance for the injury factors, **$P < 0.01$ indicates a very statistical significance for the injury factors.
CL: confidence level

Supplementary Table 2 Univariate and multivariate analysis results of wrist injuries

Risk factor		Crude odds ratio		Adjusted odds ratio	
		OR (95% CL)	*P*	OR (95% CL)	*P*
Age		0.981 (0.955–1.008)	0.168		
Dominate hand		1.42 (0.879–2.296)	0.152		
Dancing time		0.95 (0.915–0.987)	**0.008****	0.958 (0.921–0.997)	**0.037***
Breakdance instructors		0.766 (0.545–1.076)	0.124		
Specialized skill	Footwork	1.808 (1.298–2.517)	**<0.01****	1.591 (1.078–2.349)	**0.019***
	Freeze	0.809 (0.581–1.127)	0.21		
	Toprock	1.125 (0.581–1.568)	0.862		
	Powermove	0.665 (0.476–0.928)	**0.016***	0.887 (0.598–1.316)	0.551
Knowledge of sports injury protection	Very much	1.756 (0.869–3.547)	0.117		
	Partly understand	1.855 (1.117–3.08)	**0.017***	1.885 (1.115–3.189)	**0.018***
	A little	1.907 (1.179–3.084)	**0.008****	1.808 (1.101–2.972)	**0.019***
Warm up time	None	0.526 (0.173–1.599)	0.257		
	5–10min	0.569 (0.223–1.454)	0.239		
	10–20 min	0.897 (0.341–2.359)	0.825		
	20–30 min	0.943 (0.33–2.69)	0.912		

*$P < 0.05$ indicates a statistical significance for the injury factors, **$P < 0.01$ indicates a very statistical significance for the injury factors.
CL: confidence level

Supplementary Table 3 Univariate comparison of risk factors between knee injury group and wrist injury group

Risk factors	Knee injury (n=175)	Wrist injury (n=216)	*P*
Injury type			0.658
Acute injury	76 (43.4%)	89 (41.2%)	
Chronic injury	99 (56.6%)	127 (58.8%)	
Injury location			0.79
Indoor	146 (83.4%)	178 (82.4%)	
Outdoor	29 (16.6%)	38 (17.6%)	
Injury environment			**<0.01****
Training	146 (83.4%)#	203 (94%)#	
Cypher	18 (10.3%)	9 (4.2%)	
Competition	11 (6.3%)	4 (1.9%)	
Injury movement			**<0.01****
Toprock	3 (1.7%)	2 (0.9%)	
Footwork	97 (55.4%)#	11 (5.1%)#	
Freeze	12 (6.9%)#	51 (23.6%)#	
Powermove	44 (25.1%)#	151 (69.9%)#	
Others	19 (10.8%)#	1 (0.4%)#	
Cause of injury			**<0.01****
Falling	59 (33.7%)#	39 (18.1%)#	
Slipping	3 (1.7%)	2 (0.9%)	
Straining	19 (10.9%)#	14 (6.5%)#	
Spraining	46 (26.3%)#	95 (44%)#	
Self-limb collision	19 (10.9%)	28 (13%)	
Others	29 (16.6%)	38 (17.6%)	
Damage type			**<0.01****
Fractures and dislocations	4 (1.3%)	9 (2.5%)	
Muscle straining	20 (6.7%)#	45 (12.4%)#	
Soft-tissue contusion	45 (15.2%)	49 (13.5%)	
Tendon injury	52 (17.5%)	54 (15.4%)	
Tenosynovitis	13 (4.4%)#	89 (24.6%)#	
Osteoarthritis	33 (11.1%)#	18 (5%)#	
Intra-articular soft-tissue injury	81 (27.3%)#	22 (6.1%)#	
Open injury	1 (0.3%)	1 (0.3%)	
Organ damage	7 (2.4%)	5 (1.4%)	
Nerve damage	5 (1.7%)	12 (3.3%)	
Others	36 (12.1%)	57 (15.7%)	

Self-assessment injury reason			**<0.01****
Fatigue	53 (30.5%)#	76 (36.6%)#	
Lack of skills training	59 (33.5%)#	85 (41.7%)#	
Ground issue	14 (8.2%)	14 (6.5%)	
Unfitted clothes and shoes	3 (1.7%)	1 (0.3%)	
Choreography issues	22 (12.5%)	15 (7.9%)	
Dancing difficulty issue	10 (5.6%)	12 (6.2%)	
Others	24 (13.7%)	13 (7.1%)	
Dancing forms when injured			0.35
Regular or routine movement	80 (45.7%)	109 (50.5%)	
Freestyle	95 (54.3%)	107 (49.5%)	

*$P < 0.05$ indicates a significant difference between the knee and wrist injury, **$P < 0.01$ indicates a very significant difference between the knee and wrist injury. # indicates that there are significant differences within each subgroup.