



Relationship between physical activity and individual mental health after traumatic events: a systematic review

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ABSTRACT

Background: Traumatic events can cause social tension, anxiety, panic and other psychological crises, and can even cause post-traumatic stress disorder (PTSD) and suicide. Physical activity has a good role in promoting mental health, and has a great application prospect in individual psychological intervention after traumatic events. However, no systematic review of the relationship between physical activity and individual mental health after traumatic events affecting many people has been published so far, which makes it impossible for people to understand the research status in this field from a holistic perspective.

Objective: This review explores the relationship between physical activity and individual psychology, physiology, subjective quality of life and well-being after traumatic events, so as to provide some valuable clues or enlightenment for individual psychological intervention after traumatic events.

Method: Relevant literature was searched in five databases, summarised, sorted and studied.

Results: Thirty-three study papers were included in this review, the main study findings include: (1) Physical activity is positively correlated with individual mental resilience and subjective well-being after traumatic events, and negatively correlated with anxiety, depression, tension and PTSD. (2) Individuals with higher levels of physical activity have better mental health status after traumatic events than those who do not regularly engage in physical activity. (3) Physical activity can promote sleep quality, self-efficacy, subjective quality of life and various physiological functions of those experiencing traumatic events. (4) Physical activity (including exercise) is regarded as one of the preferred nursing measures to buffer against mental stress and maintain physical and mental health for those experiencing traumatic events.

Conclusion: The level of physical activity is positively correlated with individual physical and mental health before and after traumatic events. Physical activity can be used as one of the effective measures to improve individual mental health after traumatic events.

Relación entre actividad física y salud mental individual tras eventos traumáticos: Una revisión sistemática

Antecedentes: Los eventos traumáticos pueden causar tensión social, ansiedad, pánico y otras crisis psicológicas, e incluso pueden causar Trastorno de Estrés Postraumático (TEPT) y suicidio. La actividad física tiene un buen rol en la promoción de salud mental y tiene una gran aplicación prospectiva en intervención psicológica individual tras eventos traumáticos. Sin embargo, no se han publicado revisiones bibliográficas sobre la relación entre la actividad física y la salud mental individual tras eventos traumáticos que afectan a un gran número de personas, lo cual hace imposible para la gente poder entender el estado de investigación en este campo desde un punto de vista holístico.

Objetivo: Esta revisión explora la relación entre la actividad física y psicología, fisiología, calidad de vida subjetiva y bienestar individuales después de eventos traumáticos, a fin de proporcionar algunas pistas valiosas o aclaraciones para la intervención psicológica individual después de eventos traumáticos.

Método: Se buscó literatura relevante en cinco bases de datos, luego fue resumida, clasificada y estudiada.

Resultados: Treinta y tres estudios fueron incluidos en esta revisión, los principales hallazgos de los estudios fueron: 1) La actividad física se correlaciona de forma positiva con resiliencia mental individual y bienestar subjetivo luego de eventos traumáticos, y se correlaciona negativamente con ansiedad, depresión, tensión y TEPT. 2) Individuos con altos niveles de

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关键词

体育活动; 锻炼; 创伤性事件; 心理健康; 关系

HIGHLIGHTS

- Physical activity can be used as one of the important measures to improve mental health of those experiencing traumatic events.
- Regular physical activity can reduce the impact of traumatic events on mental health, both before and after the events.

actividad física tienen un mejor estado de salud mental luego de eventos traumáticos en comparación con aquéllos que no se involucran regularmente en actividad física. 3) La actividad física puede promover la calidad del sueño, la autoeficacia, calidad de vida subjetiva y varias funciones psicológicas de quienes experimentan eventos traumáticos. 4) La actividad física (incluyendo el ejercicio) es considerada como una de las medidas de enfermería preferidas para amortiguar el estrés mental y mantener la salud física y mental de quienes experimentan eventos traumáticos.

Conclusión: El nivel de actividad física se correlaciona positivamente con la salud individual física y mental antes y después de eventos traumáticos. La actividad física puede ser usada como una de las medidas efectivas para mejorar la salud mental individual tras eventos traumáticos.

创伤事件后体育活动与个体心理健康的关系：一项系统综述

背景: 创伤性事件会导致社交紧张、焦虑、恐慌等心理危机，甚至会导致创伤后应激障碍（PTSD）和自杀。体育活动对心理健康具有良好的促进作用，在创伤事件后的个体心理干预中具有很大的应用前景。然而至今尚无对影响多人的创伤性事件后体育活动与个体心理健康之间关系的系统综述发表，使得人们无法从全局视角了解该领域的研究现状。

目的: 探讨创伤事件后体育活动与个体心理、生理、主观生活质量和幸福感的关系，以此为创伤事件后个体心理干预提供一些有价值的线索或启示。

方法: 在5个数据库中检索相关文献，进行归纳、整理和研究。

结果: 本综述共纳入 33 篇研究论文，主要研究发现包括：1) 体育活动与创伤事件后的个体心理韧性和主观幸福感呈正相关，与焦虑、抑郁、紧张和 PTSD 呈负相关。2) 体育活动水平高的个体在创伤事件后的心理健康状况好于不经常进行体育活动的个体。3) 体育活动可以促进创伤性事件经历者的睡眠质量、自我效能感、主观生活质量和各种生理机能。4) 体育活动（包括运动）被认为是减轻创伤性事件患者心理压力、维持身心健康的首选护理措施之一。

结论: 体育活动水平与个体创伤前后的身心健康呈正相关。体育活动可以被用作创伤事件后改善个体心理健康的有效措施之一。

It was found that experiencing traumatic events might put individuals at risk for a variety of short-term and long-term mental health problems (Bell & Folkherth, 2016; Gillies et al., 2016; Gulliver et al., 2021; Norris et al., 2002; Zhang et al., 2022). Traumatic events can be caused by various natural disasters, accident disasters, public health accidents and social security events (Cushing & Braun, 2018). In recent years, with the increasing global population and the continuous change of climate and environment, the incidence of various ethnic conflicts and terrorism, natural disasters and modern wars has been increasing, resulting in the frequency of traumatic events reaching the highest level since World War II (United Nations High Commissioner for Refugees, 2015). Therefore, individual psychological intervention after traumatic events is not only an important part of the post-disaster rescue work of government departments in various countries, but also a hot issue of common concern to many scholars.

For a long time, the studies on individual psychological intervention after traumatic events have mainly focused on the fields of psychology and pharmacology. Psychological intervention methods such as cognitive behavioural therapy (CBT), eye movement desensitisation and reprocessing (EMDR) (Ursano et al., 2004) and critical incident stress debriefing (CISD) (Mitchell et al., 2003) are the main methods currently. The cognitive-behavioural and exposure-based

psychological interventions can effectively solve the dysfunctional cognitive and affective processing of various traumatic events, and significantly reduce all kinds of psychological symptoms such as anxiety, depression and PTSD after traumatic experiences (Watts et al., 2013). However, they cannot help everyone reduce their PTSD symptoms (Corrigan & Hull, 2015). Because cognitive, language-based interventions require a substantial amount of cognitive processing, yet, traumatic experiences can seriously impair people's cognitive functions and cause cognitive dysfunction (Van der Kolk, 2016). Therefore, trauma-related cognitive malfunction may reduce the efficacy of cognitive-behavioural therapy (Kuhfuß et al., 2021). In addition, exposure-based interventions frequently used in cognitive-behavioural therapy lead to high dropout rates due to the confrontational, aversive and even stigmatised nature of the intervention (Lewis et al., 2020). In terms of pharmacotherapy, monoamine oxidase inhibitors (MAOI) iproniazid and tricyclic anti-drugs (TCAs) imipramine are still the 'gold standard' for the treatment of severe depression, anxiety and other mental diseases (López-Muñoz & Alamo, 2009). However, long-term medication not only has side effects, but also increases the economic burden of patients seriously. Therefore, it is urgent to explore new psychological interventions or new approaches that can successfully complement existing ones.

Since the twenty-first century, the role of physical activity in individual psychological intervention after various traumatic events has gradually attracted attention of many scholars. It has been confirmed that physical activity has a unique role in maintaining physical and mental health, improving mental disorders and relieving mental stress, as well as assisting in the treatment of mental disorders such as anxiety and depression (Chen et al., 2020), and it can change the physiological and emotional processing of those experiencing various traumatic events in a 'bottom-up' rather than 'top-down' way (van der Kolk, 1994). Compared with psychotherapy and pharmacotherapy, physical activity has significant advantages such as low 'stigmatization', few side effects and strong popularity, and it has even been regarded by relevant scholars as a strategy to improve public mental health after major emergencies (Tomata et al., 2015). In 2020, the World Health Organization (WHO) formulated the Guidelines on Physical Activity and Sedentary Behavior (WHO guidelines on physical activity and sedentary behavior, 2020), which developed individually a more detailed physical activity programme for children, adolescents, adults, the elderly, pregnant women, chronic patients and other specific groups. These programmes provide important references and bases for physical activity intervention in individual mental health after traumatic events, and further arouse people's interest in this research field.

This study provides a systematic review of the relationship between physical activity and individual mental health after traumatic events affecting many people, providing a holistic view of the current research in this field. The other purpose of this study is to provide some valuable clues and enlightenment for individual psychological intervention after traumatic events.

1. Method

1.1. Identifying the research questions

Given the novelty of research in this field and the heterogeneity of the existing literature, we decided to adopt the recommendations of Arksey and O'Malley (2005), maintaining a broad approach to cover a wide range of studies and topics. In the initial stage, we conducted an exploratory literature research. After screening the results, we specified inclusion and exclusion criteria in an iterative process to focus on the three central research questions present in the field: a) What do we know about the relationship between physical activity and individual psychology, physiology, subjective quality of life and well-being after various traumatic events? b) What is the feasibility of taking physical activity as a strategy to improve individual mental health after traumatic

events? c) What is the attitude of those experiencing traumatic events to physical activity (including exercise) as a mental health improvement measure?

1.2. Data sources and search strategies

After identifying the research questions in this review, we conducted literature search according to the following search strategies. The keywords of English-language literature were 'major emergencies', 'natural disasters', 'accident disasters', 'public health incidents', 'social security incidents', 'floods', 'earthquake', 'war', 'tsunami', 'terrorist attack', 'COVID-19', 'psychological crisis', 'mental health', 'social psychology', 'physical activity', 'exercise intervention', 'exercise' and 'physical exercise', the search databases were China National Knowledge Infrastructure, WanFang Data, PubMed, Springer and ScienceDirect, and literature was searched up to December 2022.

The literature search formula was ('major emergencies' or 'natural disasters' or 'accident disasters' or 'public health incidents' or 'social security incidents' or 'floods' or 'earthquake' or 'war' or 'tsunami' or 'terrorist attack' or 'COVID-19') and ('psychological crisis' or 'mental health' or 'social psychology') and ('physical activity' or 'exercise intervention' or 'exercise' or 'physical exercise').

1.3. Eligibility criteria

The literature was screened using the following inclusion and exclusion criteria. Inclusion criteria: 1) Peer-reviewed journal articles or clinical research project reports published in English in the above databases. 2) Studies on psychological crises, mental health and psychological intervention of the experienced or survivors of specific traumatic events (e.g. natural disasters, accident disasters, public health incidents and social security incidents). 3) The full text is available. 4) Quantitative and qualitative research articles associated with exercise/ physical exercise intervention on the psychology of the experienced or survivors of various emergencies. 5) Quantitative and qualitative research articles exploring the relationship between exercise/ physical activity and mental health of the experienced or survivors of various emergencies.

Exclusion criteria: 1) Literature repeatedly published or detected. 2) Literature where the full text was not available. 3) Literature whose study methods lack scientificity.

1.4. Data extraction

Data extraction forms were used to systematically extract the following information from each study included: study country, study design, demographic characteristics of participants, the emergencies

participants had experienced, sample size, psychological assessment tools and key results.

1.5. Data synthesis

Narrative synthesis was used to analyse the results of all included studies, and group the results into themes. Finally, descriptive data was used to summarise the study (see Table 1).

1.6. Quality assessment

First of all, the quality of the included literature was subjectively assessed by two members of the study group who had long been engaged in social psychology and exercise psychology. Thereafter, the structured tool developed by Brooks et al. (2021) was used to assess the quality of the final included papers from three aspects: study design, data collection and methodology, analysis and interpretation of results.

2. Results

2.1. Literature inclusion

A total of 947 English papers were obtained after preliminary search, of which 939 were searched from the database and 8 were supplemented by other resources. Among the 947 papers, 101 were duplicates and were deleted. After that, 394 and 330 papers were deleted based on the title and abstract, respectively. Then 89 were deleted for various reasons after final screening of the remaining 122 papers. A PRISMA diagram illustrating the screening process was shown in Figure 1.

In terms of publication time, among the 33 papers, 1 was published in 2021, 12 in 2020, 2 in 2011, and the remaining 18 were published between 2011 and 2020. Most of them were from Japan ($n = 18$), and else China ($n = 2$), Spain ($n = 1$), Italy ($n = 2$), Australia ($n = 1$), Canada ($n = 1$) and the United States ($n = 7$). In terms of study design, there were cross-sectional survey ($n = 17$), prospective study ($n = 4$), randomised controlled study ($n = 6$), longitudinal cohort study ($n = 2$), longitudinal tracking study ($n = 1$), ethnographic study ($n = 1$), self-control study ($n = 1$) and structured interview ($n = 1$). The types of emergencies involved in these studies mainly focused on natural disasters such as earthquakes and extreme droughts ($n = 12$), accident disasters ($n = 8$), public health incidents ($n = 7$) and social security events such as wars and terrorist attacks ($n = 6$). The respondents included children, adolescents, middle-aged and elderly people, veterans, middle school students, company employees, journalists and photojournalists who often faced traumatic events, as well as medical personnel involved in disaster relief. The included studies were summarised in Table 1.

2.2. The relationship between physical activity and mental health of those experiencing traumatic events

All of the 33 studies included in this review explored the relationship between exercise/ physical activity and individual mental health after emergencies. Among them, only one study (Kondo et al., 2019) found that physical activity was a risk factor for individual mental health after disasters. In this study, Kondo et al. (2019) collected data of 557 diabetic patients from 13 months before the Kumamoto earthquake to 13 months after the earthquake, and multiple regression analysis showed that the level of PTSD in diabetic patients after the earthquake was positively associated with the increase of physical activity/ exercise, and negatively associated with sleep quality. The remaining 32 studies all found that exercise/ physical activity had a positive effect on the mental health of post-disaster residents.

2.2.1. The intervention effect of physical activity on mental health

Prospective studies showed that the depressive symptoms of the elderly in the disaster areas increased significantly after the earthquake in Tokyo, Japan. A 1-hour physical training programme twice a month for 1 year (including exercises suitable for the fitness level of participants, such as muscle strength training, balance training and walking exercise) could significantly reduce the incidence of functional disability (hazard ratio = 0.27, 95% CI: 0.16–0.46, HR = 0.30, CI: 0.12–0.74) and depression (hazard ratio = 0.30, 95% CI: 0.12–0.74) of the elderly after the earthquake (Kuroda et al., 2018). Consistent results were also reported by Tomata et al. (2015) in a randomised controlled study. Nozue et al. (2017) conducted a cross-sectional survey of 6668 young, middle-aged and elderly people and found that interventions aimed at physical activity and dietary intake were of great significance to improve the physical and mental health Tokyo earthquake survivors. A randomised controlled study conducted by Whitworth et al. (2019) also found that resistance training for 3 weeks, 3 times/week, 30 min/time could significantly reduce the symptoms of avoidance ($d = 1.26$, 95% CI: 0.39–2.14) and hyperarousal ($d = 0.90$, 95% CI: 0.06–1.74) in people experiencing traumatic events. Shivakumar et al. (2017) conducted a 12-week moderate-intensity exercise programme (30–40 min, 3 mph walking, 4 times/week) on 31 female veterans who had experienced war trauma, and the self-control results showed that the PTSD symptoms of the subjects decreased significantly after the intervention (z score = -2.395 , $p = .017$). Hall et al. (2020a; 2020b) conducted a randomised controlled study among 54 veterans and found that 12 weeks of multicomponent exercise

Table 1. A list of the relationship between physical activity and the mental health of people experiencing traumatic events.

Type of accidents	Name of accidents	Authors	Nationality	Study design	Survey/subjects	Sample numbers	Psychological assessment tools	Main findings
Natural disasters	Tokyo earthquake	Tomata et al. (2015)	Japan	Randomised control	Middle aged and elderly people (aged 37–88)	81	Six-item Kessler Psychological Distress Scale (K6)	Physical activity could reduce the mental distress and disuse syndrome of disaster residents and improve the subjective quality of life.
	Tokyo earthquake	Kuroda et al. (2018)	Japan	Prospective study	The aged (>65 years old)	1159	Self-assessment Basic Checklist (BCL)	Comprehensive exercise (strength, balance and aerobic exercise, etc.) for 1 year, 2 times/month, 60 min/time could significantly reduce depression level of the elderly after the earthquake and improve their well-being.
	Tokyo earthquake	Tsuji et al. (2017)	Japan	Prospective study	The aged (>65 years old)	3567	15-item Geriatric Depression Scale (GDS)	Group exercise or regular walking could significantly reduce depressive symptoms of elderly survivors after an earthquake.
	Tokyo earthquake	Goodwin et al. (2020)	Japan	Prospective study	Adults (≥18 years old)	2599	K6	There was a significant positive correlation between higher physical activity level and lower mental distress.
	Tokyo earthquake	Moriyama et al. (2019)	Japan	Randomised control	The aged (>65 years old)	21	Japanese version of the World Health Organization Five Well-Being Index (WHO-5-J)	Combined exercise intervention (walking, physical fitness lectures, etc.) lasting for 3 months and once a week could improve the subjective well-being after the earthquake.
	Tokyo earthquake	Utsumi et al. (2020)	Japan	Cross-sectional survey	Adults (>20 years old)	718	K6; Center for Epidemiologic Studies Depression Scale (CES-D); the Impact of Event Scale-Revised (IES-R)	Walking time was negatively correlated with the depressive symptoms of residents in the post-earthquake area, and walking for 30–60 min every day worked best.
	L'Aquila earthquake, Italy	Valenti et al. (2012)	Italy	Cross-sectional survey	Adolescents (aged 14–18)	179	Minnesota Multiphasic Personality Inventoried Adolescents (MMPI-A)	Exercising at least twice a week for no less than 60 min each time could reduce the anxiety level of adolescents in the post-earthquake areas.
	Tokyo earthquake	Nozue et al. (2017)	Japan	Cross-sectional survey	Young, middle-aged and elderly people	6668	K6	Interventions targeting physical activity and dietary intake had positive effects on the physical and mental health of Tokyo earthquake survivors.
	Wenchuan earthquake	Tian et al. (2014)	China	Cross-sectional survey	Middle school students	4604	Posttraumatic stress disorder Checklist-Civilian Version (PCL-C); Structured clinical interview for DSM-IV Disorders (SCID)	High levels of physical exercise and social support were negative risk factors for PTSD.
	Yushu earthquake	Lu et al. (2020)	China	Cross-sectional survey	Middle school students	4681	the Connor-Davidson resilience scale (CDRISC)	Regular physical exercise was positively correlated with the mental resilience of adolescents after the earthquake.
	Extreme climate disasters such as droughts, floods and hurricanes	Brumby et al. (2011)	Australia	Cross-sectional survey	Farmers (≥50 years old)	1813	Depression Anxiety Stress Scales-21 (DASS-21)	Long-term droughts, floods and extreme weather events could reduce farmers' physical activity levels, increase body weight and cortisol content, leading to abdominal obesity. In the absence of intervention, weight gain, mental health and exercise levels were increasingly compromised in a spiral. Increasing physical activity of residents in farms and agricultural communities could improve circulating cortisol levels, reduce the incidence of obesity in farm men and women, and reduce mental distress.
	Xiongben earthquake	Kondo et al. (2019)	Japan	Cross-sectional survey	Diabetics	557	IES-R	Disaster-related stress levels were positively associated with 'increased amount of physical activity/exercise' and negatively associated with sleep amount.

(Continued)

Table 1. Continued.

Type of accidents	Name of accidents	Authors	Nationality	Study design	Survey/subjects	Sample numbers	Psychological assessment tools	Main findings
Accident disasters	Fukushima nuclear accident	Kukihara et al. (2014)	Japan	Cross-sectional survey	Evacuees from nuclear accident areas	241	CDRISC; Zung Self-Rating Depression Scale (ZSDS); IES-R	Good exercise habit and healthy diets could improve mental resilience and reduce PTSD and depression levels of survivors.
	Fukushima nuclear accident	Oe et al. (2018)	Japan	Longitudinal cohort	Children (aged 6–12)	8282	Emotional subscale in Strength and Difficulties Questionnaire (SDQ)	Physical activity was an important protective factor for mood and peer relationships of children and adolescents after a disaster.
	Fukushima nuclear accident	Orui et al. (2018)	Japan	Cross-sectional survey	Adults (≥ 20 years old)	233	K6	Regular physical activity was positively correlated with the mental recovery of the disaster-stricken residents in the seven years after the nuclear accident, and negatively correlated with mental distress.
	Fukushima nuclear accident	Orui et al. (2017)	Japan	Cross-sectional survey	Company employees	394	K6	Physical exercise and adequate sleep were important protective factors for the mental health of post-disaster residents.
	Fukushima nuclear accident	Itagaki et al. (2017)	Japan	Cross-sectional survey	Children and adolescents (aged 6–15)	10824	SDQ	Adolescents with exercise habit (i.e. daily, 2–4 times/week or once/week) had lower median SDQ scores than those without exercise habit (never participating in physical exercise).
	Fukushima nuclear accident	Itagaki et al. (2021)	Japan	Longitudinal cohort	Children (aged 6–12)	7013	SDQ	Lack of exercise habits was one of the important risk factors for peer relationship problems and severe psychological symptoms in children and adolescents in the five years after a nuclear accident.
	traumatic event	Whitworth et al. (2019)	U.S.A	Randomised control	Adults (aged 18–45)	30	Posttraumatic Stress Diagnostic Scale for DSM-5 (PDS5); State-Trait Anxiety Inventory (STAI); The Center for the Epidemiological Studies of Depression Short Form (CESD)	Resistance training of 30 min/time, 3 times/week for 3 weeks could significantly reduce the symptoms of avoidance and hyperarousal, and improve sleep quality and hazardous alcohol use.
trauma and disaster events	Buchanan and Keats (2011)	Canada	ethnographic study	journalists and photojournalists	31	–	Exercise and other physical activities were considered as effective strategies to buffer against personal trauma, disaster events and work-related stress.	
Public health incidents	COVID-19	Jacob et al. (2020)	England	Cross-sectional survey	Adults (aged 35–64)	902	Becks Anxiety Inventory (BAI); Becks Depression Inventory (BDI); The short Warwick-Edinburgh Mental Well-being Scale	Moderate-to-high-intensity physical activity was negatively correlated with anxiety, depression and other adverse mental conditions.
	COVID-19	Carriedo et al. (2020)	Spain	Cross-sectional survey	Adults (aged 16–82)	1795	CDRISC	Regular vigorous physical activity was associated with higher self-efficacy and mental resilience.
	COVID-19	Maugeri et al. (2020)	Italy	Cross-sectional survey	Young, middle-aged and elderly people	2524	Psychological General Well Being Index (PGWBI)	The total energy consumption of physical activity could reduce the negative impact of the epidemic on mental health.
	COVID-19	Deng et al. (2020)	China	Cross-sectional survey	Young people (aged 18–22)	1607	DASS-21	Mental health was positively correlated with exercise habits or duration.
	COVID-19	Zhang et al. (2020)	China	Cross-sectional survey	Children and adolescents	9979	Profile of Mood States Scale (POMS)	Physical activity had a significant positive impact on the emotional state of children and adolescents during the epidemic.
	COVID-19	Chen et al. (2020)	China	Cross-sectional survey	Adolescent girls (aged 11–18)	4805	CES-D	Low level of physical activity was the main cause of emotional deterioration and an independent risk factor for depressive symptoms.
COVID-19	Zhang et al. (2020)	China	Longitudinal tracing	College students	66	DASS-21		

		Physical activity could directly alleviate general depression, anxiety, stress and other negative emotions.						
Social security accidents	War	LeardMann et al. (2011)	USA	Prospective study	Male veterans	38883	PCL-C; Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV)	Exercise activity, especially vigorous activity, was negatively associated with post-traumatic stress disorder of veterans.
	War	Shivakumar et al. (2017)	USA	Self-control	Female veterans	31	Clinician-Administered PTSD Scale (CAPS)	Twelve weeks of moderate-intensity aerobic exercise could be used as an intervention for PTSD in women.
	war	Hall et al. (2020a)	USA	Randomised control	Veterans	54	CAPS, PCL-C	Comprehensive exercise intervention (including aerobic exercise, strength, flexibility and balance) of 12 weeks, 3 times/week, 60–90 min/time could improve the subjective quality of life in veterans, reduce PTSD and depression, especially negative cognition and re-experience symptoms in PTSD.
	War	Goldstein et al. (2018)	USA	Randomised control	Veterans	47	CAPS	Comprehensive physical exercise (aerobic exercise and strength training) conducted collectively for 12 weeks, 3 times/week, 60 min/time could reduce PTSD symptoms.
	'9.11' terrorist attack	Smith et al. (2019)	USA	Structured interview	Emergency workers and paramedics involved in the rescue	54	-	Active physical exercise, good nutrition and adequate sleep were the preferred nursing measures to maintain their physical and mental health.

intervention (including aerobic, muscle strengthening, flexibility and balance training) could significantly reduce PTSD (mean difference = -4.23 , $d = 0.38$, 95% CI: $-11.7-3.3$) and depressive symptoms (mean difference = -3.28 , $d = 0.57$, 95% CI: $-6.8-0.3$) of elderly veterans who had experienced war trauma. Goldstein et al. (2018) also conducted a randomised controlled experimental study on veterans, and the results showed that comprehensive physical activity (aerobic exercise, strength training) performed in groups for 12 weeks, 3 times/week, 60 min/times could reduce PTSD symptoms ($d = -0.90$). The above results show that exercise after major emergencies can reduce individual psychology, such as anxiety, depression and PTSD, and have a good intervention effect on individual mental health.

2.2.2. The protective effect of physical activity on mental health

Tsuji et al. (2017) conducted a prospective study among 3567 elderly people who had undergone the 2011 Tokyo earthquake and found that the increase of individual exercise participation frequency ($B = -0.139$, $\beta = -0.049$, $p = .003$) and daily walking duration ($B = -0.087$, $\beta = -0.034$, $p = .054$) was associated with the lower 15-item Geriatric Depression Scale (GDS) score after correcting for all covariates including personal disaster experience. Similar results were also reported by Goodwin et al. (2020). Utsumi et al. (2020) divided 718 adults who had experienced the Tokyo earthquake into long-time walking group (>60 min/day), medium-time walking group (30–60 min/day) and short-time walking group (<30 min/day) according to daily walking duration. The results of analysis of covariance showed that there were significant differences in the scores of Center for Epidemiologic Studies Depression Scale (CES-D) and Six-item Kessler Psychological Distress Scale (K6) ($p = .01$, $p = .04$) among the three groups with age, gender and alcohol drinking habit as covariates, CES-D score was obviously higher among short-time walkers ($p = .004$), and walking for 30–60 min every day had the best effect. Another cross-sectional survey of 179 adolescents (14–18 years old) also showed that adolescents who regularly exercised before the earthquake (at least twice a week, no less than 1 h each time) had significant lower levels of anxiety after the earthquake than those who did not regularly exercise (-3.43 ± 0.78 , $p = .00$), in addition, the anxiety score of adolescents who often exercised after the earthquake was 3.43 points lower than that of those who did not exercise (Valenti et al., 2012). Tian et al. (2014) studied 4604 Chinese adolescents after the Wenchuan earthquake, and the results of multiple logistic regression analysis showed that high levels of physical exercise (Odds = 0.655, $p = .03$, 95%CI: 0.479–0.863) and social support (Odds = 0.977,

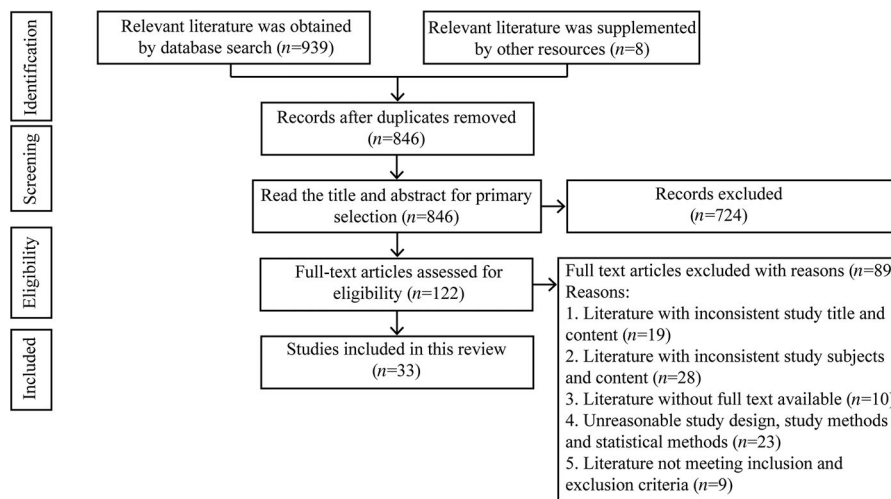


Figure 1. PRISMA flow diagram.

$p < .01$, 95%CI: 0.965–0.988) were negative risk factors for PTSD of adolescents after the earthquake. Brumby et al. (2011) also reported that increasing physical activity of residents in farms and agricultural communities in the long-term droughts, floods and extreme weather events could improve circulating cortisol levels, reduce the incidence of obesity and mental distress. Kukihara H et al. also reported that individuals with poor exercise habits were more depressed than controls among Fukushima nuclear accident survivors ($t = 3.09$, $p < .01$). Relatively consistent results were also reported by Oe et al. (2018), Orui et al. (2018), Orui et al. (2018). Itagaki et al. (2017) divided 10,824 children and adolescents aged 6–15 in the evacuation area after the Fukushima nuclear accident into exercise group (i.e. daily, 2–4 times/week or once a week) and non-exercise group (hardly participated in exercise), and the results showed that the median Strength and Difficulties Questionnaire (SDQ) score of exercise group (9[25%–75% CI:5–13]) was significantly lower than that of non-exercise group (10 [25%–75% CI:7–15]) ($p < .001$), suggesting who did not exercise regularly in the evacuation area were at higher risk of mental problems, regular exercise was very important to maintain children's mental health after disasters and could be used as an important protective factor in maintaining the mental health of adolescents after disasters. Jacob et al. (2020), Deng et al. (2020), Zhang et al. (2020) and Zhang et al. (2020) conducted cross-sectional surveys and longitudinal tracking studies on social groups of various age groups (children, adolescents, youth, the middle-aged and the elderly) during COVID-19 and found that moderate to high-intensity exercise/ physical activity was negatively associated with adverse psychologies such as anxiety, depression and stress, while mental health status was positively associated with exercise habit or exercise duration. LeardMann et al. (2011) followed up 38,883 US veterans (77% male) for 3–5 years, and

found that people who kept on vigorous physical activity (≥ 20 min, twice or more times weekly) after discharge had lower rates of new-onset (OR = 0.58, 95% CI: 0.49–0.70) and persistent (OR = 0.59, 95% CI: 0.42–0.83) symptoms of PTSD and milder symptoms even though they had experienced war trauma. Conversely, the reduced levels of exercise/ physical activity in all age groups due to social isolation during the epidemic could negatively affect mental health and lead to mood deterioration (Maugeri et al., 2020; Zhou et al., 2020). A study even found that lack of exercise habit was one of the important risk factors for peer relationship problems (OR = 2.054, 95%CI: 1.498–2.815) and severe emotional symptoms (OR = 1.435, 95%CI: 1.121–1.837) in children and adolescents in the five years after the Fukushima nuclear accident. In summary, exercise/ physical activity was an important protective factor for individual mental health after major natural disasters such as earthquake, extreme droughts and floods, and public health incidents such as Fukushima nuclear accident and COVID-19. On the contrary, insufficient exercise/ physical activity became an important risk factor.

2.2.3. Acceptability of physical activity intervention

Two studies investigated the acceptability of exercise intervention for people experiencing trauma or disaster events. Buchanan and Keats (2011) conducted an ethnographic study among 31 Canadian journalists and photojournalists who frequently faced trauma and disaster events and the results showed that exercise and other physical activity were generally viewed positively, along with avoidance strategies and use of dark humour, were regarded as effective strategies to buffer against personal trauma, disaster events and work-related stress. The results of a structured interview study conducted by Smith et al. also showed that active physical exercise, good nutrition and

adequate sleep were the preferred physical and mental health care measures for medical staff involved in the rescue of the 9.11 terrorist attacks (Smith et al., 2019).

2.3. The relationship between physical activity and subjective quality of life of those experiencing traumatic events

In addition to focusing on the effect of exercise on the psychology of people experiencing emergencies, three studies focused on the effect of exercise on subjective quality of life. A randomised controlled study conducted by Tomata et al. (2015) showed that the intervention measures to promote physical activity in disaster-stricken areas after the earthquake in Tokyo, Japan could not only prevent the mental distress and disuse syndrome of disaster area residents, but also improve individual subjective quality of life. Hall et al. (2020a; 2020b) also reported that 12 weeks of multicomponent exercise intervention (including aerobic, muscle strengthening, flexibility and balance training) improved individual subjective quality of life (mean difference = 3.19, $d = 0.36$, 95%CI: -2.7–9.1) while reducing PTSD and depression symptoms in veterans. Goldstein et al. (2018) also reported that comprehensive physical activity (aerobic exercise, strength and strength training) performed in group for 12 weeks, 3 times/week, 60 min/time could improve the quality of life of veterans ($d = 0.30$).

2.4. The relationship between physical activity and subjective well-being of those experiencing traumatic events

In a prospective cohort study, Kuroda et al. (2018) found that, while reducing the incidence of functional disability and depression in the elderly after the Tokyo earthquake and Fukushima nuclear accident, exercise also improved individual subjective well-being. Moriyama et al. (2019) randomly divided the elderly who experienced the Tokyo earthquake into control group ($n = 7$) and intervention group ($n = 14$). After 3 months of combined physical activity (walking, physical fitness lectures, etc.) in the intervention group, the median variation from the baseline in the WHO Five Well-Being Index scores of the control and intervention groups was -1.0 and -2.0 points, respectively, with statistically significant difference ($p = .06$). Utsumi et al. (2020) also found in a cross-sectional study that exercise (walking) could be used as an effective strategy to improve the mental health and subjective well-being of disaster area residents after the earthquake.

2.5. The relationship between physical activity and mental resilience of those experiencing traumatic events

Lu et al. (2020) reported in a cross-sectional survey study that regular physical exercise was positively associated with the mental resilience of middle school students in disaster-stricken areas in the five years after the earthquake ($p < .05$). Kukihara et al. (2014) also found that physical exercise habit and a good diet could improve the mental resilience of survivors after the Tokyo earthquake, tsunami and Fukushima nuclear accident while reducing PTSD and depression level of residents in disaster-stricken areas ($\beta = 0.22$, $p < .01$). A cross-sectional study conducted by Carriedo et al. (2020) also confirmed that individuals who regularly engaged in strenuous physical activity during the first week of COVID-19 epidemic lockdown had higher mental resilience ($\beta = 0.040$, $p < .01$).

2.6. The relationship between physical activity and peer relationships of those experiencing traumatic events

A longitudinal cohort study conducted by Itagaki et al. (2021) found that lack of exercise habit was one of the important risk factors for peer relationship problems (OR = 2.054, 95%CI: 1.498–2.815) and severe psychological symptoms (OR = 1.435, 95%CI: 1.121–1.837) in children and adolescents in the five years after the Fukushima nuclear accident, suggesting that exercise habit was very important not only for the mental health of evacuees after a nuclear disaster, but also for maintaining their peer relationships.

2.7. The relationship between physical activity and physiological function of those experiencing traumatic events

Hall et al. (2020a) also reported that 12-week multicomponent exercise intervention (including aerobic, muscle strengthening, flexibility and balance training) improved aerobic endurance level (Cohen's $d = 0.50$), physical performance, cardiometabolic risk factors and health related quality of life (Cohen's $d = 0.28$ – 1.48) while reducing PTSD and depressive symptoms in veterans.

2.8. Other aspects

In a randomised controlled study, Whitworth et al. (2019) found that resistance training of 30 min/time, 3 times/week for 3 weeks could not only significantly reduce PTSD symptoms in people experiencing traumatic events, but also significantly improve sleep quality ($d = 1.31$, 95% CI: 0.41–2.21) and hazardous alcohol use ($d = 1.31$, 95% CI: 0.41–

2.21). Carriedo et al. (2020) also reported that, during the first week of COVID-19 epidemic lockdown, individuals who regularly engaged in vigorous physical activity had a more optimistic mood ($\beta = 0.040$, $p < .01$) and self-efficacy ($\beta = 0.028$, $p < .05$), even after controlling for gender variables. Hall et al. (2020a) also reported that 12-week multicomponent exercise intervention, including aerobic, muscle strengthening, flexibility and balance training, could improve sleep quality in veterans (mean difference = -1.47 , $d = 0.61$, 95% CI: $-3.0-0.5$). Valenti et al. (2012) also reported that exercise (at least twice a week, no less than 1 h each time) could have a good regulation effect on the personality problems of adolescents after the earthquake.

2.9. Study quality

A structured tool developed by Brooks et al. (2021) was used to assess the quality of the included papers, calculating the total percentage of 'yes' answers to the quality assessment questions for each study (see Figure 2). The overall quality of the papers was high, with scores above 70% except for two studies scoring between 60% and 70%. Most of the included papers scored highly in study design, with 18 papers scoring 100% in this section. Scores for data collection and methodology were more mixed, with only four papers gaining full marks, and the other studies tending not to describe the number of participants at each stage of the study or explain reasons for loss to follow-up. 10 papers scored 100% for the analysis and interpretation of the results, and the rest generally did not adjust for potential confounding variables, or did not report their data with appropriate caveats, or did not provide answers to the study questions.

3. Discussion

3.1. The relationship between physical activity and mental health of those experiencing traumatic events

Among the 33 research papers included in this study, except for 3 (Carriedo et al., 2020; Lu et al., 2020; Moriyama et al., 2019) which explored the relationship between exercise/physical activity and individual subjective well-being and mental resilience after traumatic events, the other 30 explored the relationship between exercise/physical activity and individual mental health. Overall, the findings of this study support the hypothesis that physical activity can be used as an effective intervention for individual mental health after traumatic events, and are consistent with those of most previous studies. Among these 33 papers, only one found that increasing physical activity/exercise after disaster

events (earthquakes) could increase PTSD symptoms and stress levels in individuals (Kondo et al., 2019). It should be noted that 557 diabetes patients were investigated in this study. The other 32 studies did not specify whether the participants suffered from other underlying diseases, but the results tended to be consistent, that is, exercise/physical activity had a positive role in promoting physical and mental health, mental resilience, subjective well-being, quality of life and so on after various traumatic events. Among them, 8 studies used exercise as an intervention method (Goldstein et al., 2018; Hall et al., 2020a; 2020b; Kuroda et al., 2018; Moriyama et al., 2019; Shivakumar et al., 2017; Tomata et al., 2015; Whitworth et al., 2019). After 3 weeks to 1 year of exercise intervention (including aerobic exercise, muscle strengthening, flexibility and balance training, physical fitness lectures, etc.), it was found that individuals who had experienced earthquakes (Kuroda et al., 2018; Moriyama et al., 2019; Tomata et al., 2015), wars (Goldstein et al., 2018; Hall et al., 2020a; 2020b; Shivakumar et al., 2017) and other traumatic events (Whitworth et al., 2019) significantly improved their anxiety, depression, PTSD and other psychological symptoms, improved their quality of life and subjective well-being, and reduced their mental distress. Another cross-sectional study showed that interventions targeting physical activity and dietary intake had positive effects on the physical and mental health of Tokyo earthquake survivors (Nozue et al., 2017). All the above results suggested that physical activity can be used as an effective intervention for individual psychological health after traumatic events. An additional 21 studies explored the relationship between exercise/physical activity and mental health. Among them, the studies of Valenti et al. (2012) and Kukihara et al. (2014) were the most representative, the studies found that adolescents who often participated in exercise before the earthquake and Fukushima nuclear

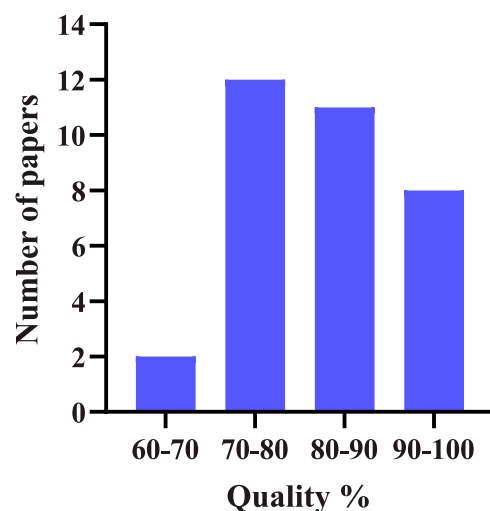


Figure 2. Scores for overall quality.

accident had a lower level of individual anxiety after the earthquake and nuclear accident than those who did not often participated in exercise, that is, good exercise habit was an important protective factor for individual psychological health after emergencies. In addition, 19 studies showed that high levels of physical activity were negative risk factors for individual anxiety, depression, stress, PTSD and other psychological symptoms of those who experienced traumatic events such as earthquake (Goodwin et al., 2020; Lu et al., 2020; Tian et al., 2014; Tsuji et al., 2017; Utsumi et al., 2020), Fukushima nuclear accident (Itagaki et al., 2017; Itagaki et al., 2021; Oe et al., 2018; Orui et al., 2018; Orui et al., 2018), extreme weather disasters (drought, flood) (Brumby et al., 2011), COVID-19 (Carriedo et al., 2020; Deng et al., 2020; Jacob et al., 2020; Maugeri et al., 2020; Zhang et al., 2020; Zhang et al., 2020; Zhou et al., 2020) and war (LeardMann et al., 2011). On the contrary, lack of exercise/physical activity was positively associated with individual mood deterioration and peer relationship problems. The above results suggested that high levels of physical activity could prevent individual psychological health from stress injury caused by various traumatic events, which was an important embodiment of the protective effect of physical activity on mental health. Other valuable studies, such as Rosenbaum et al. (2015a), Powers et al. (2015), Ramos-Sanchez et al. (2021) and Kochi et al. (2017) also confirmed the good intervention effect of exercise on PTSD, depression and anxiety in individuals and animal models through randomised controlled study, meta-analysis and other studies. As these studies did not meet the inclusion criteria of this review, we did not include them in the results analysis. Nevertheless, these valuable studies still provide strong support for the results of this study.

3.2. The role of physical activity in promoting the mental health of those experiencing traumatic events

Physical activity includes not only physical movement in the course of daily work, housework, transportation and recreation, but also planned exercise aimed at improving health, such as aerobic exercise, strength exercise and flexibility training. Among the 33 articles included in this study, 8 studies had implemented exercise intervention (such as aerobic exercise, muscle strengthening, flexibility and balance training) for 3 weeks to 1 year respectively for people who had experienced earthquakes (Kuroda et al., 2018; Moriyama et al., 2019; Tomata et al., 2015), wars (Goldstein et al., 2018; Hall et al., 2020a; 2020b; Shivakumar et al., 2017) and traumatic events (Whitworth et al., 2019). The results showed that the psychological symptoms such as individual anxiety, depression and PTSD were significantly improved

after exercise intervention, the degree of mental distress was reduced, and individual quality of life and subjective well-being were improved. Two other articles (Buchanan & Keats, 2011; Smith et al., 2019) also reported that individuals who had experienced a variety of traumatic events tended to take exercise as the preferred nursing measure to relieve mental stress and maintain physical and mental health. In the remaining 23 articles, except for the report by Kondo et al. (2019), the other studies all found that physical activity was positively associated with individual psychological health, mental resilience and subjective well-being in different degrees after traumatic events, which was a protective factor to maintain individual psychological health. Conversely, lack of physical activity was often a risk factor for all kinds of adverse psychologies. The above results were also confirmed in a large number of animal models and meta-analysis studies (Björkman & Ekblom, 2022; Hegberg et al., 2019; Oppizzi & Umberger, 2018; Rosenbaum et al., 2015b; Seo et al., 2019). The World Health Organization 2020 guidelines on physical activity and sedentary behaviour (WHO, 2020) also stated that for adults, good mental health benefits (reduced anxiety and depression symptoms) could be achieved by 150–300 min of moderate-intensity aerobic exercise per week, or 75–150 min of higher-intensity aerobic exercise, or an equivalent combination of both. For children and adolescents, mental health benefits (reduced depression symptoms) could be achieved with an average of 60 min of moderate to higher-intensity aerobic exercise per day per week. In addition to the mental benefits, increasing physical activity levels could also improve physical health (cardiopulmonary health, muscle health), cardiometabolic health (blood pressure, dyslipidemia, insulin resistance). Therefore, physical activity can be used as an effective strategy to improve individual mental health after traumatic events. It should be emphasised that physical activity can be increased in a variety of ways in real life, for example, it can be achieved not only through housework, walking to and from work and increasing physical work, but also through organised and purposeful exercise. Therefore, as an effective measure to improve individual mental health after traumatic events, physical activity has significant advantages of convenience and economy, which is especially practical for residents in relatively backward areas with low overall cultural quality.

3.3. Study limitations

This paper systematically reviews the relationship between physical activity and individual mental health after various traumatic events (natural disasters, accident disasters, public health and so on), which is of

great significance for comprehensively understanding the current research status in this field, but it also has some obvious limitations. First of all, the evaluation and review of the literature in this study is qualitative rather than a meta-analysis or quantitative process. In addition, the lack of randomised controlled studies is also a deficiency of the field. Of the 33 articles included, only 6 are randomised controlled studies (Goldstein et al., 2018; Hall et al., 2020a; 2020b; Moriyama et al., 2019; Tomata et al., 2015; Whitworth et al., 2019). Even the only 6 randomised controlled studies did not analyse the extent to which physical activity improved the mental health of those experiencing traumatic events, nor did they explore the extent to which the mental state of those experiencing traumatic events naturally improved over time. Another limitation is that the included literature covers a wide variety of traumatic events (such as natural disasters, accident disasters, public health accidents), and the differences in methodologies, participants and outcomes across papers make comparisons difficult. The types of trauma experienced by participants differed greatly, with some studies providing physical activity as a preventive measure, while others delivering it to participants already diagnosed with PTSD. Some researchers studied the relationship between physical activity and the mental health of those experiencing traumatic events, while others studied the effect of physical activity on mental health. The difference between physical activity and exercise is also responsible for the inconsistent findings in the literature.

4. Conclusion

Despite inconsistent findings, most studies supported the positive effect of physical activity on the mental health of people experiencing traumatic events. Individuals who regularly engage in high levels of physical activity before traumatic events had less psychological crisis after traumatic events, and physical activity showed a good protective effect. Active physical activities after traumatic events could reduce the stress stimulation caused by traumatic events, reduce depression, anxiety, PTSD and other psychological symptoms, improve individual well-being, subjective quality of life and peer relationships, and physical activity showed a good intervention effect. The review concludes that physical activity is positively correlated with the mental health of those experiencing traumatic events, improving physical activity can produce good benefits for individual mental health after various traumatic events.

Ethics declarations

Because no data were involved in this manuscript, ethical approval was not required.

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Zhifeng Wang wrote the first draft of the paper; Bing Jiang and Xingtong Wang mainly searched and collected relevant literature, and drew PRISM flow diagram; Zhixiang Li and Dongxu Wang were responsible for the quality assessment and classification of the literature; Haihong Jiang analysed the feasibility of the study; Dongmei Wang was responsible for the study design, and revised, translated and submitted the paper.

Disclosure statement

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Data availability statement

No data were analysed in relation to this manuscript.

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