Archives of Rehabilitation Research and Clinical Translation (2022) 4, 100207

ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Rehabilitation Research and Clinical Translation

Archives of Rehabilitation Research and Clinical Translation 2022;4:100207

Available online at www.sciencedirect.com

REVIEW ARTICLE

Effectiveness of (Active) Lifestyle Interventions in People With a Lower Limb Amputation: A Systematic Review

Sybel Van Helm, BSc [a], Leonie Adriana Krops, PhD [b], Rienk Dekker, MD, PhD [b], Aline Hendrike Vrieling, MD, PhD [b]

[a] *University of Groningen, University Medical Center Groningen, Center for Human Movement Sciences, Groningen, The Netherlands*
[b] *University of Groningen, University Medical Center Groningen, Department of Rehabilitation Medicine, Groningen, The Netherlands*

KEYWORDS
Amputation;
Healthy Lifestyle;
Exercise;
Diet;
Smoking;
Alcohol Drinking;
Self-Management;
Rehabilitation

Abstract *Objective:* To explore the effectiveness of (active) lifestyle interventions for the health of people with a lower limb amputation in order to offer effective interventions during rehabilitation that may improve physical and psychosocial functioning of people with lower limb amputation.
Data Sources: PubMed, CINAHL and Embase were searched from inception to February 2021.
Study Selection: Inclusion criteria were (1) (quasi-)randomized controlled trial; (2) minimum of 10 participants with a lower limb amputation; (3) lifestyle intervention focusing on physical activity, smoking habits, alcohol use, nutrition, and/or stress management; (4) focus on health outcomes; (5) participants older than 18 years; (6) studies in Dutch, German, or English; and (7) primary research. Title, abstract, and full-text screening and quality assessment were performed by 2 independent assessors.
Data Extraction: Of 2460 studies identified, 13 studies were included in this review. Two studies were of moderate methodological quality, 2 studies were of medium quality, and 9 studies were of poor quality.
Data Synthesis: Lifestyle interventions in the included studies focused on physical activity and stress management. These interventions seemed effective for improving physical fitness, walking capacity, changes in body mass, quality of life, and intensity of physical activity.
Conclusion: Lifestyle interventions focusing on physical activity and stress management seem effective for improving physical and psychosocial functioning of people with a lower limb amputation. However, the findings should be interpreted with caution given the limited methodological quality of the included studies. Future research should evaluate the effectiveness of

List of abbreviations: DM, diabetes mellitus; LLA, lower limb amputation; PAD, peripheral arterial disease; RCT, randomized control trial; VO_{2max}, maximal oxygen consumption; VR, virtual reality.
Disclosures: none.
Cite this article as: Arch Rehabil Res Clin Transl. 2022;4:100207

https://doi.org/10.1016/j.arrct.2022.100207

interventions on nutrition, smoking habits, and alcohol use and the effectiveness of combined interventions in people with a lower limb amputation.

A lower limb amputation (LLA) negatively affects physical health (decreased physical capacity and increased pain), psychosocial well-being, and quality of life.[1] The main reasons for performing an LLA in Western European countries and the Unites States are peripheral arterial disease (PAD), with a prevalence of 90%, and trauma, with a prevalence of 6%.[2,3] People with an LLA due to PAD often have additional underlying chronic diseases, such as diabetes mellitus (DM), chronic obstructive pulmonary disease, or heart failure. These underlying diseases must be taken into account when considering the lifestyle of people with an LLA. In the last decade, the number of people with an LLA in the population aged 63 years and older decreased from 142.6 per 100,000 person-years from 2003-2004 to 89.2 per 100,000 person-years from 2012-2013.[4] This decrease is most likely caused by improved medical care and lifestyle management for people with DM and PAD, such as counseling on smoking habits, innovations in pharmacotherapy,[5] and improved knowledge on glycemic control.[6]

'Lifestyle' is used as an umbrella term for the following health behaviors: physical activity, smoking habits, alcohol use, nutrition, and stress management. These behaviors are discussed in more detail below. Throughout this study, a lifestyle intervention is defined as an intervention that includes either individual coaching or group session(s) aimed at improving at least 1 of the health outcomes in domains of the International Classification of Functioning (activity, participation, and body functions and structure) through (behavioral) strategies focused on physical activity, smoking habits, alcohol use, nutrition, and stress management. This definition was adapted from a definition by Lv et al.[7] The format of the sessions should be in-person (human coaching) or remote by telephone or online (human coaching or automated coaching).

Physical activity

Participating regularly in physical activity and sports both before and after an LLA enhances psychological well-being, self-confidence, and coping behavior.[8,9] People with a unilateral transtibial amputation due to vascular reasons are less physically active compared to able-bodied people.[10] Eleven to 61% of people with an LLA participate regularly in physical activities or sports, the latter being a specific subset of physical activity.[8] Swimming, fitness, cycling, fishing, sailing, and golf are practiced most by people with an LLA. Barriers to participating in physical activity or sports are pain, lack of programs specially organized for people with an LLA, embarrassment, and lack of knowledge of existing sport facilities.[8]

A sedentary lifestyle before an LLA due to PAD is also associated with decreased physical fitness afterwards. The relatively long period of hospitalization and immobility that can occur due to slow healing of the residual limb decreases physical fitness.[2,11] Physical fitness can be attained through training, but vulnerability of the residual limb has to be taken into account.[12]

Quality of life in people with an LLA is influenced by the ability to walk with a prosthesis, which likely results from the fact that walking facilitates the ability to live independently and improves participation in social activities.[13] A healthy and active lifestyle, including physical and lifestyle interventions, may positively affect the ability to walk (ie, walking speed, walking time during the day, and distance walked) in people with an LLA and, consequently, improve the ability to participate in physical activity, which results in enhanced quality of life.[10] Walking ability is influenced by level of amputation, comorbidity, psychological motivation, living situation, and social functioning.[13] In people with an LLA, the energy cost of walking has changed. Walking with a prosthesis requires more oxygen consumption compared with able-bodied walking.[14] Furthermore, oxygen consumption increases with a more proximal amputation level and when walking speed increases. Increased energy consumption is caused by inefficiency of prosthetic walking.[14-19] The higher energy cost of walking in people with an LLA may negatively affect their physical activity behavior.

In nondisabled populations and people with other mobility disabilities, physical activity interventions were found to be effective for increasing physical activity behavior and health outcomes.[8,9,20] The research agenda for physical activity in people with mobility disabilities stresses the need for further research on the effectiveness of physical activity and combined lifestyle interventions. Recently, the first global physical activity and sedentary behavior guidelines for people living with disabilities were published, stressing the importance of physical activity in this population.[21,22]

Smoking

Smoking increases the risk of PAD. In smokers with PAD, the amputation rate was found to be 2 to 3 times higher compared with that for nonsmokers with PAD.[23-25] Also, smokers have a 3 times higher risk of re-amputation than nonsmokers.[23] Smoking cessation has received increasing attention in primary as well as secondary and tertiary health care. Rehabilitation centers, for instance, often offer interventions for smoking cessation.

Alcohol

Excessive consumption of alcohol, defined as more than 2 alcoholic drinks per day, is associated with a 1.3 times higher risk of re-amputation in alcohol users compared with nonalcohol users.[26] Furthermore, people who used alcohol within 3 months after amputation were more than twice as likely to be diagnosed with an overuse musculoskeletal injury in lower and upper limbs and with lower back pain 4 to 12 months after amputation.[27]

Nutrition

People with an LLA have a higher risk of obesity and development of obesity-related comorbidities, such as DM or cardiovascular disease. According to the Health Survey for England 2011, 29.5% of all people with an LLA are obese and 54.4% are overweight, compared with 24%-26% and 33%-41% of able-bodied people, respectively.[28] The higher number of overweight people can be attributed to insufficient physical activity or inadequate nutrition. Unhealthy dietary habits, mainly in terms of fat, sugar, and salt intake, are not unknown to many people with an LLA.[29] Furthermore, the level of amputation influences weight gain. Two years after amputation, people with a more proximal amputation had an 8%-9% weight gain on average, whereas people with a more distal amputation had a 3%-6% weight gain.[30]

Stress management

An LLA may lead to psychosocial challenges, such as negative effects on self-confidence and body image. Likely causes for these effects are changes in employment status and a decrease in physical functioning. These stressors challenge the ability of people to maintain their emotional well-being.[31] Shortly after amputation, well-being is negatively associated with greater posttrauma anxiety and psychological distress, whereas in the long term, rehabilitation results in better adaptation to limitations.[31,32] Length of time after amputation greatly affects how people with an LLA cope with their situation. A longer period of time after amputation is associated with less posttrauma anxiety and psychological distress. For people with an LLA and their loved ones, training in coping with psychosocial changes after an LLA is important. Improved coping strategies are associated with higher levels of physical and psychosocial functioning.[31] Stress management therapies, including holistic approaches, pastoral care, and mindfulness, may reduce psychological distress and improve acute and long-term recovery after an LLA.[33]

In conclusion, lifestyle habits have a considerable impact on the health and well-being of people with an LLA. Healthy lifestyle habits are associated with a lower risk of primary LLA (primary prevention).[5] Moreover, maintaining a healthy lifestyle decreases the risk of medical complications and re-amputation after LLA (secondary prevention)[23] and is associated with higher quality of life (tertiary prevention).[13] Therefore, it is important to offer effective interventions aimed at optimizing the lifestyle of this population. Different interventions for (among others) people with an LLA are offered not only in welfare programs and primary health care but also in secondary and tertiary health care (eg, hospitals and rehabilitation centers). Numerous examples exist of interventions that target 1 (ie, smoking cessation coaching in hospital care) or multiple lifestyle factors (ie, combined lifestyle programs during rehabilitation). Though the effectiveness of these programs is summarized in reviews for other populations, to the best of our knowledge there is no systematic overview of the effectiveness of lifestyle interventions in people with an LLA. This systematic review therefore aims to explore the effectiveness of lifestyle interventions on health, well-being, participation, and functioning of people with an LLA. In addition, this review provides evidence-based support for health care providers to coach people with an LLA in achieving or maintaining an optimal lifestyle, thereby optimizing health outcomes and quality of life.

Methods

Search strategy

PubMed, CINAHL, and Embase were searched from inception. MeSH terms (if supported by the database) and free-text words were combined into a search string using Boolean operators (OR/AND). Search terms used were amputation, lifestyle, physical activity, smoking, alcohol, nutrition, diet, food intake, stress management, and relaxation. The complete search strategies are shown in Appendix 1. The search was performed on March 3, 2020. A search update using the same search strategy was performed on February 14, 2021.

Study selection

Combined title and abstract screening was performed after removing duplicates. The following inclusion criteria were applied: (1) randomized controlled trial (RCT) and quasi-RCT (a trial in which participants are divided into different groups using a method of allocation that is [not truly] random); (2) men and women ≥18 years with an LLA; (3) number of participants ≥10; (4) lifestyle intervention focused on physical activity, smoking habits, alcohol use, nutrition, and/or stress management; (5) all health-based outcomes were in the domains of the International Classification of Functions scale; (6) studies were in Dutch, German, or English; and (7) primary research.

During the full-text screening, the inclusion criteria from title and abstract screening were extended by adding the following inclusion criteria: (1) description of the protocol was available; (2) outcome parameters were defined; and (3) the study was published as a full paper

The methods for inclusion and analysis were specified and documented in a protocol (PROSPERO: CRD42020175392).

Title, abstract, and full-text screening and quality assessment of the included articles were performed independently by 2 assessors (A.H.V. and S.v.H.). In case of disagreement among assessors, a consensus meeting was held and, when necessary, a third independent assessor was consulted (R.D.). It was unclear whether or not some of the physical activity interventions retrieved by the search included a behavioral component. To be as complete as possible, we decided to include these interventions in this review and subdivide physical activity interventions into physical training interventions and behavioral interventions targeting physical activity.

Data extraction

Data were extracted for number of participants, content of the intervention and control group, duration of the intervention, causes for amputation, time after amputation, level of amputation, uni- or bilateral amputation, age, sex, lifestyle of participants before or after the amputation, and health outcomes.

Quality assessment

Included articles were screened for potential bias, applying the Cochrane tool for assessing risk of bias in randomized trials (RoB 2 tool).[34,35] This tool classifies the quality of the following domains: study design, risk of bias, inconsistency, indirectness, imprecision, and publication bias.

Results

Study selection

In total, 2460 studies were retrieved by the search strategy. After removing duplicates, 1701 studies remained for title and abstract screening, of which 1660 studies were excluded. Of the 41 studies selected for the full-text screening, 28 were excluded because they did not meet the inclusion criteria. Main reasons for exclusion were not being primary research, not meeting language restrictions, or not being a (quasi-)RCT. Cohen's kappa for title/abstract screening was 0.95 (0.80 for the search update) and it was 0.87 for full-text screening (0.68 for the search update), which is considered (very) good. A total of 13 studies were included in this systematic review (figure 1).

Study characteristics

Tables 1 and 2 describe the characteristics of the studies included in this systematic review. Three quasi RCTs, 1 cross-over RCT, and 9 RCTs were included. Included studies were performed in North America (n=5), Asia (n=4), Europe (n=3), and Africa (n=1). Sample sizes ranged from 14 to 154, and people with all different amputation levels (toe to transfemoral) and of different etiologies were included (table 1). Of the 13 included studies, 11 focused on interventions to stimulate physical activity. One of the 11 studies also focused on managing body weight. Two of the 13 studies focused on stress management. No research was found on the effects of lifestyle interventions regarding nutrition, smoking habits, and alcohol use in people with an LLA.

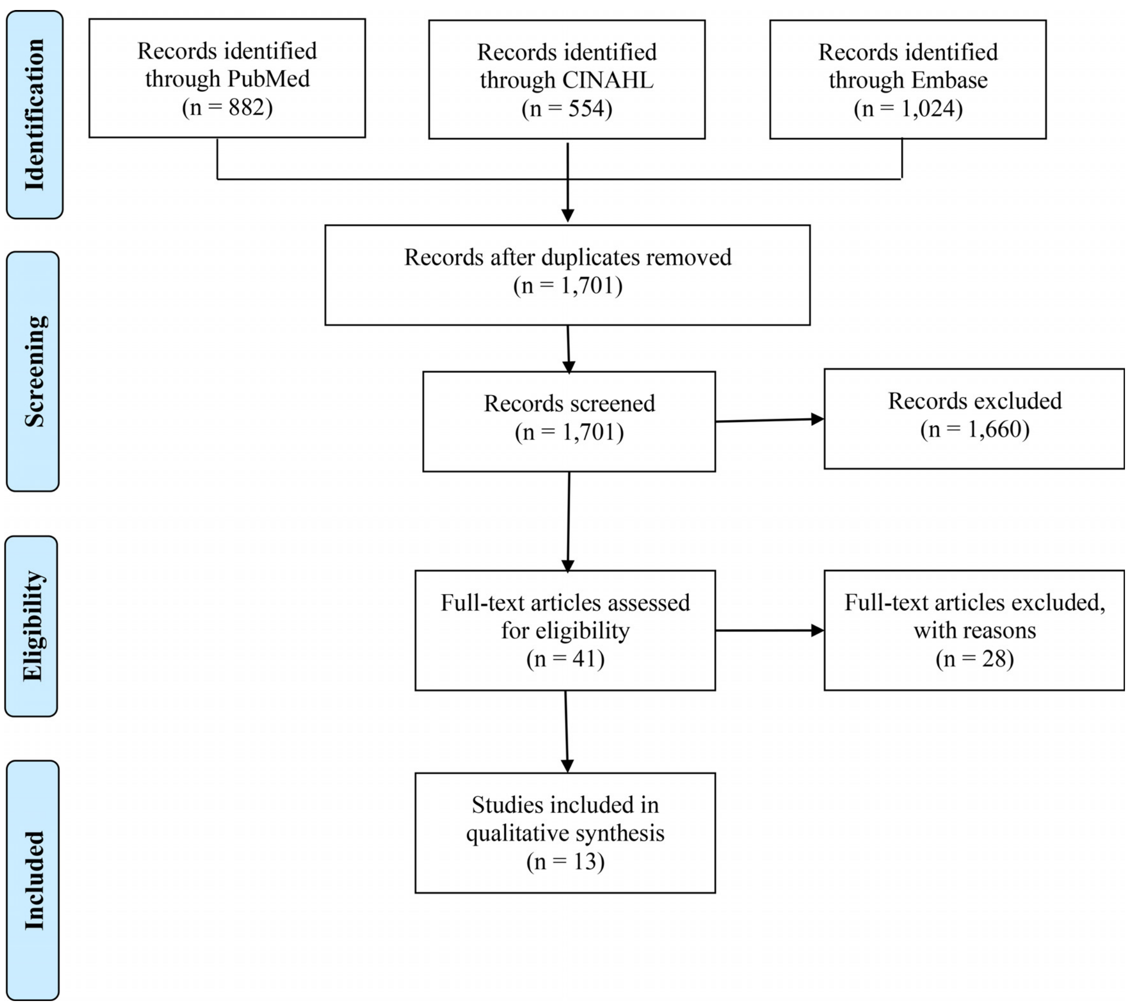

Fig 1 Flowchart of data search.

Table 1 Study characteristics and characteristics of the study populations of the included studies

Study	Study Design	Country	Setting	Sample Size (Sex)*	Age	Cause of Amputation	Level of Amputation	Time After Amputation
Chin et al[36]	Quasi RCT	Japan	Hospital	I: n=14 (unknown) C: n=10 (unknown)	I: 39.8±12.4 y C: 41.2±18.4 y	Trauma	24 UL TF	Unknown
Nolan[37]	Quasi RCT	Sweden	Rehabilitation center	I: n=8 (6) C: n=8 (5)	I: 41.1±8.4 y C: 49.0±9.1 y	Trauma, tumor, and congenital	I: 4 TT, 3 TF, and 1 BL (1 limb TT, 1 TF) C: 3 TT, 5 TF	1.0-34 y
Imam et al[38]	RCT	Canada	Rehabilitation center/home	I: n=14 (12) C: n=14 (6)	I: mean 61.5 y C: mean 62.5 y	PAD (12), trauma (15), and cancer (1)	I: 8 UL TT and 6 TF C: 7 UL TT and 7 TF	>1 y
Rau et al[39]	RCT	Myanmar	Rehabilitation center	I: n=29 (unknown) C: n=29 (unknown)	I: 36.39±10.90 y C: 35.24±7.99 y	Trauma and cancer	I: 21 TT and 8 TF C: 22 TT and 7 TF	I: 11.34±8.13 y C: 9.66±5.76 y
Schafer et al[40]	RCT	United Kingdom	University/home	I: n=7 (4) C: n=8 (7)	I: 60±12 y C: 65±16 y	PAD, trauma, cancer, infection (osteomyelitis)	I: 2 TT and 5 TF C: 3 TT and 5 TF	0.3-49 y
Schafer et al[41]	RCT	United Kingdom	University/home	I: n=7 (4) C: n=7 (0)	I: 60±12 y C: 63±17 y	PAD (5), trauma (4), other (5)	I: 2 TT and 5 TF C: 2 TT and 5 TF	I: 10±17 y C: 18±21 y
Abbas et al[42]	RCT	Lebanon	Rehabilitation center/ university/Red Cross training center	I: n=16 (15) C: n=16 (14)	I: 27.625±7.6 y C: 27.625±4 y	Trauma	I: 13 TT and 3 TF C: 13 TT and 3 TF	Unknown
Littman et al[43]	RCT	United States	Home	I: n=7 (6) C: n=8 (5)	I: mean 56 y C: mean 57 y	Trauma, infection, and cancer	I: 1 toe and 6 TT C: 1 toe, 1 TF, and 6 TT	>1 y
Christiansen et al[44]	RCT	United States	Hospital/home	I: n=19 (16) C: n=19 (19)	I: mean 62 y C: mean 65 y	DM and/or PAD	UL TT	<6 mo
Christiansen et al[45]	RCT (crossover)	United States	Home	Group 1: n=16 (16) Group 2: n=15 (15)	Group 1: 67.9±6.2 Group 2 C: 63.4±8.9 y	PAD and/or DM	I: 14 TT (88%) C: 12 TT (80%)	Group 1: 36.5±40.8 mo Group 2: 36.2±16 mo
Godlwana et al[46]	RCT	South Africa	Hospital/home	I: n=77 (49) C: n=77 (51)	I: 58.6±9.9 y C: 57.8±9.7 y	PAD and/or DM	I: 17 TF and 60 TT C: 33 TF and 44 TT	3 mo
Imeni et al[47]	RCT	Iran	Hospital	I: n=28 (23) C: n=26 (18)	I: 56.2±7.7 y C: 56.6±8.6 y	DM	I: 1 TF and 12 TT C: 2 TF and 12 TT	3-36 mo
Delehanty and Trachsel[48]	Quasi RCT	Canada	Rehabilitation center	I: n=20 (19) C: n=21 (20)	I: 58.8±13.0 y C: 64.0±14.5 y	PAD (26), DM (11), and trauma (4)	I: 10 TF, 11 TT with 5 BL C: 8 TF, 12 TT with 4 BL	>8 mo after discharge

NOTES. *n (# male).
Abbreviations: BL, bilateral; C, control group; I, intervention group; KD, knee disarticulation; TF, transfemoral; TT, transtibial; UL, unilateral.

Table 2 Description of intervention components and their effectiveness

Study	Intervention	Control Group	Frequency	Outcome Measures	Conclusion
Physical training intervention					
Chin et al[36]	Endurance training with the intact leg. Exercise at a heart rate corresponding to AT point	Ordinary prosthetic walking training	30 min/d, 3-5 d/wk for 6 wk	**AT:** 36.5% increase in intervention group (before 11.9±2.1; after 18.6±5.8; *P*<.05). Intervention more effective than control (*P*<.05) **VO_{2max}:** 26.0% increase in intervention group. Intervention more effective than control (*P*<.05)	Endurance training is more effective for improving physical fitness (AT, VO_{2max}) compared with ordinary prosthetic walking training.
Nolan[37]	Hip strength training program: warming up, balance and coordination exercises, hip strengthening exercises, and a cooling-down after each session	Same amount of exercise as usual for the past 3 mo	30-40 min/d, 2 d/wk for 10 wk	**Body mass:** significantly reduced body mass in the intervention group after training but not in the control group. However, there was no significant difference in body mass between the two groups after training **Strength:** increased hip strength in the intervention group, whereas decreased intact limb hip extensor strength in the control group **Oxygen consumption:** decreased oxygen consumption in the intervention group; no difference in the control group	Hip strength training is effective for reducing body mass and improving physical fitness and hip strength.
Imam et al[38]	Wii Fit: balance and strength training	Training using cognitive games (Wii Big Brain Academy Degree)	40 min/d, 3 d/wk for 4 wk	The intervention group showed improvement in walking measures at the end of treatment and at 3-wk retention compared with the control group **2MWT:** before: 141.1±44.0 m, after: 146.3±44.5 m (ES=0.5), at 3-wk retention: 148.5±47.4 (ES=0.6) **Walking behavior:** before: 2208±1045 steps/d, after: 2676.7±1246.7 steps/d (ES=0.2), at 3-wk retention: 2261±1194.4 steps/d (ES=0.6) **WWT:** before: 16.2±5.5 s; after: 15.2±4.8 s (ES=0.7), at 3-wk retention: 15.8±5.1 s (ES=0.5).	Wii Fit training is effective for improving walking capacity and walking behavior.
Rau et al[39]	Short intensive physiotherapy program: lower limb strengthening exercises, weight bearing, coordination tasks, corrected walking, obstacle management, and functional training	Usual care: walking under supervision	3- to 5-d program, 1 h/d (3 d for transtibial amputees and 5- to 7-d program)	**2MWT:** increase in intervention group of 20.15±17.12 m and 8.93±19.52 m in the control group. Intervention more effective than control, *P*=.024 **Walking speed:** improvement in the control group 3.94±10.15 m/min, *P*=.016	A short and intensive physiotherapy program is effective for improving functional performance.
Schafer et al[40]	Personalized exercise program: focusing on strength, balance, flexibility, and walking	No intervention	2-4 times per wk, 12 wk	**Falls:** decrease in intervention group, during 12-mo follow-up period (before: 6.1±7.4; after: 0.1±0.4; *P*=.020). Intervention more effective than control, *P*=.015 **Gait speed:** increase in intervention group (before: 0.21 m/s; after: 0.98 m/s; *P*<.001). Intervention more effective than control, *P*=.002	A personalized exercise program is effective for improving walking performance and reducing the number of falls.

(*continued*)

Table 2 (*Continued*)

Study	Intervention	Control Group	Frequency	Outcome Measures	Conclusion
Schafer et al[41]	Personalized exercise program: focusing on strength, balance, flexibility, and walking	No intervention, maintaining normal activities of daily living	2/wk supervised group exercise sessions (circuit style)+1-2/wk personalized exercise at home	**Sensory ratios** (Sensory Organization Test): no significant differences between intervention and control group (*P*>.005) **Limb asymmetry** (motor control test): intervention group showed less asymmetry during medium (*P*=.029) and large (*P*=.048) forward perturbations **Balance confidence** (ABC questionnaire): no significant differences between intervention and control groups (*P*>.005)	A personalized exercise program is effective for improving postural control.
Abbas et al[42]	Traditional rehabilitation program+VR training	Traditional rehabilitation program	Traditional rehabilitation program 20 min/session+VR training 3/wk, for 6 wk	**Balance:** DGI: increase in intervention group (before: 17.81±1.72; after: 22.75±0.93; *P*=.0004). Intervention more effective than control, *P*=.0001. BBS: increase in intervention group (before: 43.19±3.67; after: 51.38±3.10; *P*=.0002). Intervention more effective than control, *P*=.035 **6MWT:** increase in intervention group (before: 166.19±108.24 m; after: 262.63±110.92 m; *P*=.091). No significant difference between the groups	VR training is an effective and safe intervention for improving balance and gait.
Physical activity behavior interventions					
Littman et al[43]	Telephone-delivered physical activity and weight management (MOVE-LEAP)	Same materials as the intervention group. However, no coaching calls or home visits	11 10- to 20-min phone calls for 20 wk	**Anthropometrics:** Weight: Intervention group (before: 107.3±16.2 kg; after: 104.0±18.1 kg) lost more weight compared with control group (*P*=.05). Waist circumference: Intervention group (before: 121.0±14.2 cm; after: 117.7±15.5 cm) decreased more compared with control group (*P*=.03). Fat mass: Intervention group (before: 35.1±12.8 kg; after: 33.1±12.8 kg) decreased more compared with control group (*P*=.02). Lean mass: Intervention group (before: 69.8±8.8 kg; after: 67.6±9.6 kg) decreased more compared with control group (*P*=.02) **Physical functioning:** Change in 6MWT (*P*=.18) and Get Up and Go test (*P*=.23) did not differ between intervention group and control group	The home-based intervention with coaching may be effective for improving body composition but is not yet effective for improving physical functioning.
Christiansen et al[44]	Telephone sessions focusing on health behavior change targeting physical activity	Attention control group sessions focusing on health status monitoring	Weekly 30-min telephone sessions for 12 wk	**Physical function:** 2MWT: increase in intervention group (before: 86.9 m; after 24 wk: 99.8 m; *P*=.02). Gait speed: increase in intervention group (before: 0.78 m/s; after 12 wk: 0.96 m/s; *P*<.001; after 24 wk: 0.97 m/s; *P*<.001). Improvement in	The behavior change intervention is just as effective as attention control group sessions focusing on health status monitoring to improve walking capacity, but it is

(*continued*)

Table 2 (*Continued*)

Study	Intervention	Control Group	Frequency	Outcome Measures	Conclusion
				physical functioning did not differ between the control and intervention groups ($P>.05$) **Walking activity:** Daily step count: increase in intervention group (before: 1305 steps; after 12 wk: 2439 steps; $P<.001$; after 24 wk: 2294 steps; $P=.002$). Intervention group had greater improvement in daily steps compared with control group ($P=.03$). Time in activity: 4.8% decrease in sedentary activity, 4.2% increase in light-intensity activity, and 0.6% increase in moderate- or vigorous-intensity activity in intervention group. Intervention group showed a greater decrease in sedentary time compared with control group ($P=.04$)	more effective for improving walking activity.
Christiansen et al[45]	Telephone sessions focusing on health behavior change targeting physical activity in weeks 1-12 and no intervention in weeks 13-24	Attention control group sessions focusing on health status monitoring in weeks 1-12 and telephone sessions focusing on health behavior change targeting physical activity in week 13-24	Weekly 30-min telephone sessions for 12 wk	**Free-living physical activity:** Daily step count: ES=−0.15 **Participation**: LLFDI-DS: ES=−0.22 (Frequency Scale) and 0.17 (Limitations Scale) **Physical functioning:** TUG: ES=−0.10; gait speed: ES=−0.05; 2MWT: ES=−0.15; PEQ-MS: ES=−0.05 **Self-efficacy:** FES-I: ES=−0.10; SEE: ES=0.05; ESC: ES=0.39 **Social support:** MSPSS: ES=0.17 Change in all outcomes did not differ between the control and intervention groups ($P>.05$).	The biobehavioral intervention was feasible but did not result in greater improvement of outcomes compared with the control group.
Godlwana et al[46]	Home-based exercise (strengthening exercises and balance re-education) and education program +usual treatment	Usual treatment including early bed exercises to prevent edema and deformity of the stump; maintain general strength and joint mobility; and enable ambulation with crutches in the hospital wards	Daily exercises for 3 mo	**Functional participation:** Barthel index: no differences between intervention and control groups at 3 mo ($P=.097$) and 6 mo ($P=.715$). Participation Scale: fewer participation restrictions in intervention group at 3 mo ($P=.011$); no difference at 6 mo ($P=.088$) **Quality of life:** Euroqual5D VAS: intervention group superior at 3 mo ($P=.045$) and 6 mo ($P=.033$) Euroqual5D Utility Index: intervention group superior at 3 mo ($P=.025$); no difference at 6 mo ($P=.318$) **Mobility** (TUG): no differences between intervention and control groups at 3 ($P=.192$) and 6 mo ($P=.189$) **Activity limitations** (Modified Locomotor Capability Index): intervention group less limited at 3 mo ($P=.034$); no difference at 6 mo ($P=.722$)	Home-based exercise and education program is effective for improving functioning, mobility, and quality of life after 3 mo. Most intervention effects were not sustained 6 mopostintervention.

(*continued*)

Table 2 (*Continued*)

Study	Intervention	Control Group	Frequency	Outcome Measures	Conclusion
Stress management intervention					
Imeni et al[47]	Meditation: training in relaxing the muscles and deep breathing and inhaling and exhaling techniques	Training courses on diabetes care	15 min/d for 4 wk	**Body image:** Intervention group significantly improved (before: 56.60±14.90; after: 44.40±11.50; P<.001). Control group did not improve (before: 55.30±10.30; after: 53.70±8.20; P=.080)	Meditation is effective for improving individuals' body image and their mental condition.
Delehanty and Trachsel[48]	New amputee program: (a) providing information about the disease, (b) anticipating and normalizing stressors, and (c) building coping strategies	Amputee program prior to initiation of the group intervention	3 2-h group sessions over a period of 3 wk	**Activity levels:** Intervention group had significantly more holidays (2.48±1.08) compared with control group (1.75±1.06; P<.05). Other subscales did not differ between groups **Distress levels:** Intervention group had significantly less anxiety (49.00±11.32 vs 57.47±13.08), phobic anxiety (55.00±10.69 vs 63.00±11.32), and paranoid ideation (43.75±11.00 vs 52.68±9.99) compared with control group. Intervention group scored significantly lower on the general severity index (53.65±15.00) compared with control group (62.68 ±11.90). All Ps<.05.	Short-term group intervention is effective for reducing distress levels.

Abbreviations: 2MWT, 2-minute walk test; 6MWT, 6-Minute Walk Test; ABC, Activities-specific Balance Confidence-UK self-report questionnaire; AT, anaerobic threshold; BBS, Berg Balance Scale; DGI, Dynamic Gait Index; ES, effect size; ESC, Exercise Stages of Change Scale; FES-I, Falls Efficacy Scale—International; LLFDI-DS, Late Life Function and Disability Instrument—Disability Scale; MSPSS, Multidimensional Scale of Perceived Social Support; SEE, Self-Efficacy for Exercise; TUG, Timed Up and Go; VAS, visual analog scale; VO_{2max}, maximum oxygen consumption; VR, virtual reality; WWT, walking while talking test.

Methodological quality

Risk of bias was classified as “low risk in 2 of the included studies, “some concerns” in 2 of the included studies, and “high risk” in 9 of the included studies. An overview of risk of bias for each of the included studies is provided in figure 2.

Physical activity interventions

Physical training interventions

One study evaluated the effect of endurance training of the intact leg on physical fitness. After endurance training of the intact leg, physical fitness (anaerobic threshold and maximal oxygen consumption, VO_{2max}) increased significantly in a group of younger people with a unilateral transfemoral amputation due to trauma, whereas physical fitness in the control group did not change.[36] Another study indicated that hip strength training was effective for improving physical fitness (decreased oxygen consumption) and muscle strength of the intact limb hip extensor and decreasing body mass in a small group of younger people with a nonvascular LLA.[37]

In addition, there are indications that Wii Fit training is effective for improving walking behavior (number of steps) and walking capacity (2-minute walk test) in older people with an LLA.[38] A short intensive physiotherapy program, consisting of daily 1-hour sessions for 5-7 days, was found to be effective for improving walking capacity (2-minute walk test) in a group of younger people with a nonvascular LLA.[39] A 12-week personalized exercise program was found to

	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall
Chin et al. 2001 [36]	–	–	+	+	+	–
Nolan 2012 [37]	–	–	+	?	+	–
Imam et al. 2017 [38]	+	+	+	+	+	+
Rau et al. 2007 [39]	+	–	+	+	+	–
Schafer et al. 2018 [40]	?	–	+	+	+	–
Schafer et al. 2021 [41]	–	+	?	+	+	?
Abbas et al. 2021 [42]	+	+	–	+	+	–
Littman et al. 2019 [43]	+	–	+	+	+	–
Christiansen et al. 2018 [44]	+	+	+	+	+	+
Christiansen et al. 2020 [45]	+	+	?	+	+	?
Godlwana et al. 2020 [46]	+	–	+	+	+	–
Imeni et al. 2018 [47]	+	–	+	+	?	–
Delehanty et al. 1995 [48]	–	–	+	+	?	–

+ = low risk; ? = some concerns; – = high risk

Fig 2 Cochrane tool for assessing risk of bias in randomized trials (RoB 2 tool).

improve gait speed significantly from 0.21 to 0.98 m/s in a small group of older people with an LLA.[40] In another study, a similar 12-week personalized exercise program was found to be effective for improving postural control in a small group of older people with an LLA.[41] Last, adding virtual reality (VR) training to a traditional exercise program can potentially contribute to improve balance and gait in a group of younger people with amputation caused by trauma.[42]

Behavioral interventions targeting physical activity
A program that combined telephone-delivered coaching for physical activity behavior and weight management resulted in numeric but not statistically significant improvements in physical functioning and decreased body mass in a small group of older people with mostly transtibial nonvascular LAA.[43] Multiple different physical activity behavioral interventions had a positive effect on walking capacity. Walking capacity was measured by multiple parameters, such as gait speed, distance walked during the 2-minute walk test, and steps per day. First, weekly telephone sessions focusing on stimulating an active lifestyle were found to be effective for improving gait speed, distance walked in 2 minutes, and steps per day (figure 2). Furthermore, these telephone sessions resulted in significantly decreased sedentary time (4.8%), increased light-intensity activity (4.2%), and moderate-to-vigorous-intensity activity (0.6%) in a group of older people with an LLA due to PAD or DM.[44] However, a similar study that included telephone coaching was found to not be effective for improving physical activity behavioral change and participation in a group of older veterans with nontraumatic amputation.[45] Last, a combined program consisting of home-based exercise and education on physical activity was found to be effective for improving quality of life and in stimulating people to perform daily activities in a large group of older people with an LLA due to PAD or DM.[46]

Stress management interventions

Meditation sessions focusing on muscle relaxation resulted in significantly lower levels of body disturbance and improved body image and mental condition in a group of older people with mostly transtibial LLAs caused by DM.[47] Moreover, a short group intervention was found to be effective for decreasing distress levels in a group of older people with an LLA due to PAD or DM. This intervention focused on providing information about the disease (PAD/DM) and on anticipating and normalizing future stressors and on providing coping strategies to deal with the participants' situation.[48]

Discussion

This systematic review explored the effectiveness of lifestyle interventions aimed at improving the health of people with an LLA. Lifestyle interventions that focused on physical activity, smoking habits, alcohol use, nutrition, and stress management were studied. A total of 13 studies were included. Lifestyle interventions targeting physical activity and stress management could be of importance for improving health, well-being, quality of life, and functioning of people with an LLA. No (quasi-)RCTs were found that evaluated the effectiveness of interventions regarding smoking habits, alcohol use, and nutrition in people with an LLA.

Nine of the 13 included studies had a high risk of bias (figure 2), mainly because the randomization process was not truly random. This is partly due to the inclusion of quasi-RCTs. In addition, in most studies, deviations from intended interventions occurred as a result of either nonadherence to the assigned intervention or inadequate description of non-protocol interventions. Given this high risk of bias, results of the included studies should be interpreted with caution.

Based on the results of the included studies, it can be concluded that physical fitness of people with an LLA can be improved with 1-legged endurance training of the intact leg.[36] It is important to train people to walk with a prosthesis during rehabilitation after an LLA because being able to walk increases independence and results in improved quality of life.[46] Walking ability can be trained by home-based exercises with a focus on strengthening exercises and balance re-education[43] and hip strength training of the intact and the residual leg.[37] It could be recommended that people with an LLA perform strength training on a regular basis in order to avoid losing limb strength, because limb strength was found to be reduced in people with an LLA who did not follow a strength training program.[37] Besides the ability to walk, balance is an important determinant of walking ability and independence. Adding VR training to a traditional exercise program was found to be effective for training balance in young people with an LLA due to trauma and could therefore be recommended.[42]

Different interventions were found to be effective for improving walking capacity. Telephone sessions on changes in health behavior that included goal setting on exercises at home, walking activity, and disease self-management were effective for increasing gait speed, walking capacity, and daily walking behavior.[44] However, such a program was not effective for older veterans; they did not experience an increase in physical activity or changes in participation.[45] Wii Fit training focusing on balance and strength may contribute to improved daily walking behavior.[38] The participants in the Wii Fit study had different causes and levels of amputation and were of various ages.

A short and intensive physiotherapy program of 7 days maximum can be recommended to improve walking ability and walking capacity in young persons with a transtibial or transfemoral amputation due to trauma or cancer.[39] Furthermore, a personalized exercise program focusing on strength, balance, flexibility, and walking can be recommended to improve walking ability and reduce falls, resulting in fewer injuries and lower economic costs.[40] Last, a similar personalized exercise program was found to improve postural control.[41] Although the study populations in these studies were small, they nevertheless included participants of different ages and amputation levels and causes.

In general, the physical activity levels for persons with a DM-related LLA remained stable shortly after discharge from rehabilitation. Three and 9 months after discharge, however, the recommended guidelines of 6500 steps per day and 150 minutes of moderate-to-vigorous-intensity physical activity per week were not followed.[49] Increasing the level and intensity of physical activity may be the key to improve walking capacity in this population.[50]

In 2 studies, some evidence was found for the contribution of lifestyle interventions to weight loss in people with an LLA. First, hip strength training had a positive effect on reducing body mass in a group of younger people with an LLA due to cancer, trauma, or congenital causes.[37] Second, telephone-delivered physical activity and body weight management with goal setting focusing on diet, physical activity, and self-monitoring may decrease body weight in persons with LA due to nonvascular reasons. Both interventions could be advised for overweight persons with an LLA.[43] Earlier cross-sectional research demonstrated the association between body composition (body mass index, waist circumference, and body fat percentage) and physical activity levels in people with an LLA.[51]

The current review showed that stress management interventions are also beneficial. A daily 15-minute meditation program focusing on muscle relaxation for resulted in a significantly improved body image and mental condition in peoples with an LLA due to DM.[47] Also, a short-term group intervention that focused on understanding the consequences of the current and future situation and normalizing stress reactions was found to lower distress levels in people with an LLA due to vascular disease or trauma.[48] Based on these results, these types of stress management interventions could be introduced in a rehabilitation program for people with an LLA.

In conclusion, the findings of this review show that an optimal lifestyle intervention program for people with an LLA may include muscle strength and balance training, physical activity coaching with self-monitoring, and stress management.[41,46] Given the heterogeneity of the population, also in terms of physical capacity, it is vital that the intervention program be tailored to the needs of the individual person. Based on the findings of this review, it could be recommended, also based on the general principles of exercise prescription, as published by the American College of Sports Medicine,[52] that a rehabilitation program for patients with an LLA include 2 to 3 sessions of strength and balance training per week under supervision and with telephone coaching. It seems effective to offer such a program 6 months to 1 year after the LLA. People with an LLA should receive guidance on setting goals with a specific focus on physical activity and self-monitoring. In addition, it is important to add a component to the intervention that aims to reduce stress levels. An education program on the consequences of amputation, coping strategies, and meditation may reduce stress levels.

Study limitations

A limitation of the current review is that only 13 studies were eligible for inclusion. In addition, not all of the lifestyle components were covered in these studies. Most studies came from the field of physical activity. There is a lack of data on interventions related to nutrition, smoking, alcohol use, and stress management. One explanation could be that these interventions are more difficult to implement and are not always included in rehabilitation programs. Another explanation could be that these interventions were not evaluated with (quasi-)RCTs, which can be expensive to run and difficult to manage. Because the aim of this study was to evaluate the effectiveness of lifestyle interventions, this review included only (quasi-)RCTs because these are considered to be the strongest type of evidence. Therefore, potentially effective interventions might have been missed in this review if they were evaluated with different study designs; for example, a non-controlled before-after design. There is also a risk of publication bias because nonsignificant results are difficult to publish.

In addition, not all included interventions in this review focused on producing sustained, long-term behavioral changes in people with an LLA, which should ideally be the purpose of a lifestyle intervention. In many of the included articles, only immediate and short-term changes in outcomes were described, and the follow-up period was too short to conclude whether these interventions resulted in sustainable behavioral changes that were maintained after conclusion of the intervention.

Recommendations for future research

More higher quality research is needed on the effectiveness of physical activity and stress management interventions. Also, the long-term effects of lifestyle interventions in people with an LLA deserve more attention. Researchers and clinicians should focus on the development and evaluation of lifestyle interventions regarding nutrition, smoking habits, and alcohol use. These lifestyle components increase the risk of an amputation and influence medical complications, health outcomes, and, consequently, quality of life after the amputation. Different lifestyle components can also influence each other. High stress levels, for example, can limit sleep quality, which may result in reduced motivation to become physically active. For this reason, it would be useful to offer and evaluate interventions that combine different lifestyle components into 1 intervention. To the best of our knowledge, the effectiveness of such combined lifestyle interventions has not yet been studied.

Conclusions

Lifestyle interventions focusing on physical activity and stress management appear effective for improving physical and psychosocial functioning of people with an LLA. However, findings should be interpreted with caution given the limited methodological quality of the included studies. More research is needed to evaluate the effectiveness of lifestyle interventions regarding nutrition, smoking cessation, and alcohol use in people with an LLA and the effectiveness of combined interventions.

Corresponding author

S. van Helm, BSc, University of Groningen, University Medical Center Groningen, Department of Rehabilitation Medicine, Hanzeplein 1, CB41, PO Box 30.001, 9700 RB, Groningen, The Netherlands. *E-mail address:* sybel.van.helm@gmail.com.

References

1. De Godoy JMP, Braile DM, Buzatto SHG, Longo O, Fontes OA. Quality of life after amputation. Psychol Health Med 2002;7: 397-400.
2. Dillingham TR, Pezzin LE, MacKenzie EJ. Limb amputation and limb deficiency: epidemiology and recent trends in the United States. South Med J 2002;95:875-83.
3. Unwin N. Epidemiology of lower extremity amputation in centres in Europe, North America and East Asia. Br J Surg 2000;87:328.
4. Fard B, Dijkstra PU, Stewart RE, Geertzen JHB. Incidence rates of dysvascular lower extremity amputation changes in northern Netherlands: a comparison of three cohorts of 1991-1992, 2003-2004 and 2012-2013. PLoS ONE 2018;13:e0204623.
5. Parvar SL, Fitridge R, Dawson J, Nicholls SJ. Medical and lifestyle management of peripheral arterial disease. J Vasc Surg 2018;68:1595-606.
6. Bongaerts BWC, Müssig K, Wens J, et al. Effectiveness of chronic care models for the management of type 2 diabetes mellitus in Europe: a systematic review and meta-analysis. BMJ Open 2017;7:e013076.
7. Lv N, Azar K, Rosas LG, Wulfovich S, Xiao L, Ma J. Behavioral lifestyle interventions for moderate and severe obesity: a systematic review. Prev Med 2017;100:180-93.
8. Bragaru M, Dekker R, Geertzen J, Dijkstra P. Amputees and sports. Sports Med 2011;41:721-40.
9. Webster JB, Levy CE, Bryant PR, Prusakowski PE. Sports and recreation for persons with limb deficiency. Arch Phys Med Rehabil 2001;82:S38-44.
10. Bussmann JB, Grootscholten EA, Stam HJ. Daily physical activity and heart rate response in people with a unilateral transtibial amputation for vascular disease. Arch Phys Med Rehabil 2004;85:240-4.
11. Fleury AM, Salih SA, Peel NM. Rehabilitation of the older vascular amputee: a review of the literature. Geriatr Gerontol Int 2013;13:264-73.
12. Blokland IJ, van Bennekom CAM, Appel R, Groot FP, Houdijk H. Fysiek Profiel - Fysieke testen en training binnen de revalidatie. Nederlands Tijdschrift Voor Revalidatiegeneeskunde 2018: 149-52.
13. Davie-Smith F, Coulter E, Kennon B, Wyke S, Paul L. Factors influencing quality of life following lower limb amputation for peripheral arterial occlusive disease: a systematic review of the literature. London: SAGE; 2017.
14. Boonstra AM, Schrama J, Fidler V, Eisma WH. The gait of unilateral transfemoral amputees. Scand J Rehabil Med 1994;26:217-23.
15. Huang CT, Jackson JR, Moore NB, et al. Amputation: energy cost of ambulation. Archives of Physical Medicine and Rehabilitation 1979;60:18-24.
16. Jeans K, Browne R, Karol L. Effect of amputation level on energy expenditure during overground walking by children with an amputation. J Bone Joint Surg 2011;93:49-56.
17. Pinzur MS, Gold J, Schwartz D, Gross N. Energy demands for walking in dysvascular amputees as related to the level of amputation. Orthopedics 1992;15:1033-7.
18. van Schaik L, Geertzen JHB, Dijkstra PU, Dekker R. Metabolic costs of activities of daily living in persons with a lower limb amputation: a systematic review and meta-analysis. PLOS ONE 2019;14:e0213256.
19. Waters R, Perry J, Antonelli D, Hislop H. Energy cost of walking of amputees: the influence of level of amputation. J Bone Joint Surg 1976;58:42-6.
20. Conn VS, Hafdahl AR, Mehr DR. Interventions to increase physical activity among healthy adults: meta-analysis of outcomes. Am J Public Health 2011;101:751-8.
21. World Health Organization. Guidelines on physical activity and sedentary behaviour. Geneva, Switzerland: World Health Organization; 2020.
22. Carty C, van der Ploeg HP, Biddle SJ, et al. The first global physical activity and sedentary behavior guidelines for people living with disability. J Phys Act Health 2021;18:86-93.
23. Acar E, Kacıra BK. Predictors of lower extremity amputation and reamputation associated with the diabetic foot. J Foot Ankle Surg 2017;56:1218-22.
24. Dormandy JA, Rutherford RB. Management of peripheral arterial disease (PAD). TASC working group. TransAtlantic Inter-Society Consensus (TASC). J Vasc Surg 2000;31(Pt 2):S1-296.
25. Norgren L, Hiatt WR, Dormandy JA, Nehler MR, Harris KA, Fowkes FGR. Inter-society consensus for the management of peripheral arterial disease (TASC II). J Vasc Surg 2007;45:S5-67.
26. Norvell DC, Czerniecki JM. Risks and risk factors for ipsilateral re-amputation in the first year following first major unilateral dysvascular amputation. Eur J Vasc Endovasc Surg 2020;60:614-21.
27. Yepson H, Mazzone B, Eskridge S, et al. The influence of tobacco use, alcohol consumption, and weight gain on development of secondary musculoskeletal injury after lower limb amputation. Arch Phys Med Rehabil 2020;101:1704-10.
28. Sutton R. Health Survey for England—2011: Vol. 1, chapter 10: Adult anthropometric measures, overweight and obesity. Available at: https://files.digital.nhs.uk/publicationimport/pub09xxx/pub09300/hse2011-ch10-adult-obesity.pdf. Accessed September 1, 2021.
29. Westerkamp EA, Strike SC, Patterson M. Dietary intakes and prevalence of overweight/obesity in male non-dysvascular lower limb amputees. Prosthet Orthot Int 2019;43:284-92.
30. Littman AJ, Thompson ML, Arterburn DE, et al. Lower-limb amputation and body weight changes in men. J Rehabil Res Dev 2015;52:159-70.
31. Desmond DM, MacLachlan M. Coping strategies as predictors of psychosocial adaptation in a sample of elderly veterans with acquired lower limb amputations. Soc Sci Med 2006;62:208-16.
32. Livneh H, Antonak RF, Gerhardt J. Psychosocial adaptation to amputation: the role of sociodemographic variables, disability-related factors and coping strategies. Int J Rehabil Res 1999;22: 21-31.
33. Vincent HK, Horodyski M, Vincent KR, Brisbane ST, Sadasivan KK. Psychological distress after orthopedic trauma: prevalence in patients and implications for rehabilitation. PM R 2015;7:978-89.
34. RoB2 Development Group. Current version of RoB 2. Available at: https://www.riskofbias.info/welcome/rob-2-0-tool/current-version-of-rob-2. Accessed April 14, 2020.
35. Sterne JAC, Savović J, Page MJ, et al. RoB 2: a revised tool for assessing risk of bias in randomised trials. BMJ 2019;366:l4898.
36. Chin T, Sawamura S, Fujita H, et al. Effect of endurance training program based on anaerobic threshold (AT) for lower limb amputees. J Rehabil Res Dev 2001;38:7-11.
37. Nolan L. A training programme to improve hip strength in persons with lower limb amputation. J Rehabil Med 2012;44:241-8.
38. Imam B, Miller WC, Finlayson H, Eng JJ, Jarus T. A randomized controlled trial to evaluate the feasibility of the Wii Fit for improving walking in older adults with lower limb amputation. Clin Rehabil 2017;31:82-92.
39. Rau B, Bonvin F, de Bie R. Short-term effect of physiotherapy rehabilitation on functional performance of lower limb amputees. Prosthet Orthot Int 2007;31:258-70.
40. Schafer ZA, Perry JL, Vanicek N. A personalised exercise programme for individuals with lower limb amputation reduces falls and improves gait biomechanics: a block randomised controlled trial. Gait Posture 2018;63:282-9.
41. Schafer ZA, Vanicek N. A block randomised controlled trial investigating changes in postural control following a personalised 12-week exercise programme for individuals with lower limb amputation. Gait Posture 2021;84:198-204.

42. Abbas RL, Cooreman D, Al Sultan H, El Nayal M, Saab IM, El Khatib A. The effect of adding virtual reality training on traditional exercise program on balance and gait in unilateral, traumatic lower limb amputee. Games Health 2021;10:50–6.
43. Littman AJ, Haselkorn JK, Arterburn DE, Boyko EJ. Pilot randomized trial of a telephone-delivered physical activity and weight management intervention for individuals with lower extremity amputation. Disabil Health J 2019;12:43-50.
44. Christiansen CL, Miller MJ, Murray AM, et al. Behavior-change intervention targeting physical function, walking, and disability after dysvascular amputation: a randomized controlled pilot trial. Arch Phys Med Rehabil 2018;99:2160–7.
45. Christiansen CL, Miller MJ, Kline PW, et al. Biobehavioral intervention targeting physical activity behavior change for older veterans after nontraumatic amputation: a randomized controlled trial. PM R 2020;12:957–66.
46. Godlwana L, Stewart A, Musenge E. The effect of a home exercise intervention on persons with lower limb amputations: a randomized controlled trial. Clin Rehabil 2020;34:99–110.
47. Imeni M, Sabouhi F, Abazari P, Iraj B. The effect of spiritual care on the body image of patients undergoing amputation due to type 2 diabetes: a randomized clinical trial. Iran J Nurs Midwifery Res 2018;23:322–6.
48. Delehanty RD, Trachsel L. Effects of short-term group treatment on rehabilitation outcome of adults with amputations. Int J Rehabil Health 1995;1:61–73.
49. Desveaux L, Goldstein RS, Mathur S, et al. Physical activity in adults with diabetes following prosthetic rehabilitation. Can J Diabetes 2016;40:336–41.
50. Paxton RJ, Murray AM, Stevens-Lapsley JE, Sherk KA, Christiansen CL. Physical activity, ambulation, and comorbidities in people with diabetes and lower-limb amputation. J Rehabil Res Dev 2016;53:1069–78.
51. Guchan Z, Bayramlar K, Ergun N. Determination of the effects of playing soccer on physical fitness in individuals with transtibial amputation. J Sports Med Phys Fitness 2017;57:879–86.
52. Pescatello LS, Arena R, Riebe D, Thompson PD. ACSM's guidelines for exercise testing and prescription 2013. Available at: https://www.worldcat.org/title/acsms-guidelines-for-exercise-testing-and-prescription/oclc/857906042.