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ORIGINAL ARTICLE

Physical fitness, rather than self-reported physical activities, is more strongly associated with low back pain: evidence from a working population

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Abstract

Introduction Physical activity is suggested to be important for low back pain (LBP) but a major problem is the limited validity of the measurement of physical activities, which is usually based on questionnaires. Physical fitness can be viewed as a more objective measurement and our question was how physical activity based on self-reports and objective measured levels of physical fitness were associated with LBP.

Materials and methods We analyzed cross-sectional data of 1,723 police employees. Physical activity was assessed by questionnaire (SQUASH) measuring type of activity, intensity, and time spent on these activities. Physical fitness was based on muscular dynamic endurance capacity and peak oxygen uptake (VO_2 peak). Severe LBP, interfering with functioning, was defined by pain ratings $\geq$4 on a scale of 0–10.

Results Higher levels of physical fitness, both muscular and aerobic, were associated with less LBP (OR: 0.54; 95% CI: 0.34–0.86, respectively, 0.59: 95%CI: 0.35–0.99). For self-reported physical activity, both a low and a high level of the total physical activity pattern were associated with an increase of LBP (OR: 1.52; 95%CI: 1.00–2.31, respectively, 1.60; 95%CI: 1.05–2.44).

Conclusion These findings suggest that physical activity of an intensity that improves physical fitness may be important in the prevention of LBP.

Keywords Low back pain · Physical activity · Physical fitness · Lifestyle

Introduction

The significance of physical activity in the management of low back pain is generally accepted and the increase or normalization of physical activity levels has become an important aspect in recommendations related to the management of low back pain (LBP) [1]. Physical load is assumed to have both an acute and cumulative effect on the occurrence of back pain, although different dimensions of physical activity such as occupational versus sporting activities yield different relationships to LBP [2]. Strenuous physical activities, such as lifting heavy objects or working in an awkward position, are associated with a higher risk for LBP [3]. The same is true for having a sedentary lifestyle. Reduced physical activity has been linked to several chronic health problems, including chronic musculoskeletal complaints [4]. A recent analysis of data from a population based cohort shows that both extremes of the physical activity pattern are associated with a higher prevalence of LBP, suggesting that the relationship between the level of activity and LBP follows a U-shaped curve [5].

Almost all studies focusing on the relationship between physical activity and LBP are based on self-reported physical activity and the validity of self-reports on physical

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activity is limited [6, 7]. Studies that use a simplified or a not valid measure of physical activity can erroneously suggest that physical activity does not matter or is of little importance for LBP [8]. In addition, it is known that, although LBP patients state they are moderately or severely disabled and less active, they still perform activities on a rather normal level [9, 10]. Large studies using more objective measures of physical activity in relation to LBP are, however, lacking [11]. Physical fitness measurements, such as muscular capacity and maximal oxygen uptake, are objective measures that represent part of physical activity. Physical fitness is mainly, although not entirely, determined by physical activity patterns over recent weeks or months. Genetic contributions to fitness are important but probably account for less of the variation observed in fitness than is due to environmental factors, principally physical activity [12]. Maximal aerobic capacity, as assessed by maximal oxygen uptake, is closely related to the level of exertion during physical activities that involves repetitive use of large muscles, such as walking, jogging and cycling [13]. However, the amount of adaptation in fitness to the level of exertion during physical activity varies [12].

On the association between fitness measures and LBP results from the literature are contradictory. In the studies reporting on trunk muscle strength, both static and dynamic endurance tests, inconclusive evidence is reported for an association with a risk of LBP [14–19].

The levels of both physical fitness and physical activity of back pain patients appear to be lower or comparable to the fitness levels of healthy subjects [13, 20, 21] and the increase of physical activity through exercise and training has been found to be an effective preventive intervention for back- and neck pain [18, 22, 23].

We explored the relationship of self-reported physical activity and two physical fitness measures (muscular capacity and maximal oxygen uptake) with low back pain in a cohort of 1,723 police employees.

Materials and methods

Population

This study is part of the Utrecht Police Lifestyle Intervention Fitness and Training study (UP-LIFT), a voluntary fitness and lifestyle evaluation and intervention study for employees of the Utrecht police department in the Netherlands ($n = 3{,}500$). To be included in the study subjects (1) had to be part of the police department and (2) had to able to follow and complete all testing procedures. The final population comprised of 1,723 participants (1,169 men and 554 women), aged between 18 and 62 years, who visited the health research department at the University of Applied Sciences Utrecht between December 2004 and November 2008.

To gain some information on the non-response a sample ($n = 700$) of the non-responders was send a one sheet questionnaire by post. These 526 responders (75%) are expected to be representative of the non-responders and did not differ from the total responders on the main socio-demographic characteristics, such as age, gender, body mass index (BMI) and professional tasks.

All participants provided a written informed consent and approval for the study was obtained from the Ethical Committee of the Utrecht University Medical Centre.

Low back pain

Information on low back pain (LBP), sampled by means of a questionnaire was classified as ever/never LBP experience, LBP complaints during the last 12 months and current LBP. Current LBP was used in analyzing the interrelation between physical activity, physical fitness, and LBP. Intensity of current LBP was rated on a numeric rating scale, ranging between 0 (no pain) and 10 (worst possible pain). Based upon the prevalence of LBP and the implications related to direct healthcare expenditures and indirect work and disability-related losses [24], we focused on functional limiting back pain. As there is no gold standard definition of functional limiting pain, we considered pain rating scores $\geq$4 to be clinically important, i.e. interfering with functioning and we therefore used it as the cut-off point for stratification [25]. Back pain was stratified and analyzed for pain ratings <4 and $\geq$4.

Assessment of physical activity and physical fitness

Physical activity was assessed using the Short QUestionnaire to ASsess Health enhancing physical activity (SQUASH) [26]. The SQUASH is a fairly reliable and reasonably valid questionnaire and may be used to order subjects according to their level of physical activity. The Spearman correlation for overall reproducibility was 0.58 (95% CI: 0.36–0.74). Correlations for the reproducibility of the separate questions varied between 0.44 and 0.96 [27]. Participants were asked to report their average time (days per week, hours and minutes per day) and type of activity. Activities were given a metabolic equivalent value (MET), ranging between 1 and 12 METs [28]. The volume of physical activity was expressed in MET-hours (MET value multiplied by the hours spent on the activity) and divided into three categories according to level of intensity: MET-hours light (hours $\times$ activities < 4 METs), moderate (hours $\times$ activities between 4 and 6.5 METs), and high (hours $\times$ activities > 6.5 METs). The analysis was aimed upon the association of type and volume of physical activity with current LBP and was performed in two shifts. First, by analysis of the total activity pattern whereby a distinction was made between activities of a low, moderate, and high intensity. Second, by analysis of the separate dimensions of physical activity such as transport, domestic and occupational activities, gardening and other hobbies, leisure time walking, bicycling and sports.

Physical fitness was assessed by measuring muscular endurance capacity and peak oxygen uptake (VO_{2peak}). Muscular capacity was systematically measured by means of a one set of dynamic contractions of the abdominal and back muscles (40 contractions per minute) and a one-legged step test (60 contractions per minute). Abdominal and back muscle capacity were measured in a standardized performance by the use of the David 20® and 90® test- and training devices (David Sports Ltd., Finland). The one-legged step test used for measuring the extensor activity of the lower extremities was performed by one-legged eccentric flexion and concentric extensions (knee: 0°–45°–0°) while standing on a 25 cm height step. The total exertion performed was used as a measure of muscular capacity. Peak oxygen uptake (VO_{2peak}), expressed in ml/kg/min, is considered as the golden standard for exercise capacity [6]. Subjects were tested on a bicycle ergometer (Siemens-Elema 380B; Ergometrics 800S®, Ergometrics, Bitz, Germany), in a laboratory with stabilized room temperature. The initial workload of 20 W was increased every minute by 20 W until volitional exhaustion. During the test, a 12-lead electrocardiogram (ECG) and respiratory data through breath-by-breath analysis (Oxyxon Pro®, Jaeger, Mijnhardt) were continuously measured. Heart rate was calculated from the electrocardiogram. The gas analyzers and the flow meter were calibrated before each test according to the manufacturer's instructions. Oxygen uptake (VO_2) and carbon dioxide output (VCO_2) were determined from the continuous measurement of oxygen and carbon dioxide concentration in the inspired and expired air. The respiratory gas exchange ratio was calculated as VO_2/VCO_2. Testing was terminated when the subject signaled exhaustion, fatigue, shortness of breath, leg pain or pain in the chest or when ST-segment changes or a cardiac arrhythmia was noted on the 12-lead ECG. Scores on the outcome of both physical activity and physical fitness were subdivided into quartiles.

Statistical analysis

Characteristics of the population, back pain complaints, type and intensity of physical activity and level of physical fitness were assessed by comparing median scores, percentages or absolute scores (number and volume) depending on the type of variable. Relationships with back pain, stratified in pain ratings <4 and ≥4, were calculated by uni- and multivariate logistic regression analyses, including the 95% confidence intervals (95% CI). Variables included in the analyses were type and volume of physical activity (MET-hours), total exertion of the abdominal and back muscles, extensor muscles of the lower extremities, and peak oxygen uptake (ml/kg/min). Scores were categorized by quartiles with the first quartile as reference group. Physical activity and fitness variables, part of the multivariate analysis, were checked on multicollinearity. Adjustment for gender and age was performed in all the analyses. Significance for all tests was set at $P \leq 0.05$ (two-sided). Statistical analyses were performed with SPSS package version 15.0 (SPSS Inc. 2006).

Results

The study was based on 1,723 (1,169 male and 554 female) participants, aged between 18 and 62 years (mean 39.8; SD 10.4). The 12 months prevalence of self-reported LBP was 51% ($n = 879$). Point prevalence was 38.5% ($n = 664$), with a prevalence of 24.6% ($n = 424$) for numeric pain rating scores ranging <4 and 13.9% ($n = 240$) for numeric pain rating scores ≥4, defined as functional limiting pain (Table 1). Mean age of participants in the group without LBP (38.6 years; SD 10.6) varied significantly ($P \leq 0.01$) from the group with current LBP (41.7 years; SD 9.8). There were no significant differences in current pain ratings between gender and task differentiation of police employees (executive, management and support staff).

Higher levels of physical fitness, both muscular and aerobic, were strongly related with a decreased association with functional limiting LBP complaints (multivariate: OR: 0.54; 95% CI: 0.34–0.86, respectively, 0.59: 95%CI: 0.35–0.99). On the other hand, both extremes of the total physical activity pattern were associated with an increased association with LBP complaints, comparable to a U-shaped curved relation, i.e. too little or too much are both hazardous for spinal health (multivariate: OR:1.52; 95%CI: 1.00–2.31, respectively, 1.60; 95%CI: 1.05–2.44) (Table 2). The effects were more pronounced for women than for men (data not shown). The outcome of the analyses of separate types and intensity levels of self-reported physical activity varied widely and even revealed opposite results. In particular, the effects of low intensity physical activities as well as domestic activities were more strongly related with women (OR = 2.30, 95% CI: 1.05, 5.03, respectively, 3.07, 95% CI: 1.00, 9.40), whereas the effects of high load activities such as gardening were more strongly related with men (OR = 2.34, 95% CI: 1.42, 3.87) (data not shown).

Table 1 Characteristics of 1,723 participants of the Utrecht Police Lifestyle Intervention Fitness and Training Study (UP-LIFT)

	Number	Percentage
Gender		
Male/female	1,169/554	67.8/32.2
Age groups		
≤34 years	584	33.9
35–46 years	607	35.2
≥47 years	532	30.9
Professional tasks		
Executive	1,003	58.3
Management and support	716	41.7
Low back pain[a]		
Ever pain	1,187	69.1
12 months pain	879	51.0
Current pain	664	38.5
NRS 1–3	424	24.6
NRS ≥ 4	240	13.9
	Median	Range
Physical activity[b]		
Total pattern	125	3.5–430
Transportation	4.0	0–60
Domestic	21	0–210
Occupational	37	0–200
Gardening and hobbies	4	0–190
Other leisure time	12	0–229
Sports	14	0–297
Physical fitness[c]		
Muscular capacity		
Abdominal	26	2–270
Back	48	11–1,010
Lower extremity	89	12–1,103
Aerobic capacity	35.0	12.1–63.7

NRS numeric rating scale

[a] Ever pain = life prevalence; 12 months pain = year prevalence; current pain = point prevalence

[b] Physical activity = volume of physical activity in metabolic equivalents × hours/week; Transportation = transportation by walking and bicycling; Other leisure time = recreation by walking and bicycling

[c] Muscular capacity = repeated dynamic contractions of the abdominal-back muscles and lower extremity extensor muscles; Aerobic capacity = peak oxygen uptake (ml/kg/min)

Discussion

The cross-sectional data showed that high levels of objectively measured muscular fitness and aerobic fitness (VO_{2peak}) were associated with less LBP and that this was a much clearer relationship than those of self-reported physical activity with LBP. The highest level of self-reported physical activity was associated with more LBP. An explanation of this last finding may be that this group comprises persons doing too much or the wrong things, as too much sporting, high physical loading, specific sports, etc., which is comparable to a U-shaped curved relation. A U-shaped relation was also found in the DMC_3 study, a large population-based study, strengthening the idea that measuring physical activity in relation to LBP is not a matter of a dichotomy, i.e. being active or inactive, but more the concept of a continuum of activity levels with different consequences for back exertion [5].

So type and intensity of physical activity are important variables in controlling LBP. However, the main issue is the lack of accuracy in measuring the volume and intensity of daily live physical activities. For instance, inconsistent and partly unexpected relations with LBP were found. A high level of self-reported physical activity of high intensity was moderately related with less LBP (OR = 0.78, 95% CI: 0.54, 1.14), but a high level of physical activity based on the total range of activities was related with more LBP (OR = 1.50 95% CI: 1.00, 2.25).

Physical fitness can be measured in a far more controlled way. Our analyses show that higher fitness performances, being the outcome of our controlled testing procedure, are more strongly associated with less low back pain compared with the levels of PA performances as assessed by self-reported questionnaires. This may suggest that intensity of activity is probably a central element of the management of LBP. Regular physical activity, which is intense enough to contribute to higher levels of aerobe or muscular fitness, is probably important for the prevention of LBP. Within the domain of cardiovascular disease or metabolic syndrome, intensity of physical activity has already proved to be of major influence on the prevalence and prevention of these diseases [29]. The association between lower levels of aerobic fitness and LBP was also described in studies showing lower VO_{2peak} values in patients with chronic LBP compared with healthy controls [20, 21] or values similar to the physical fitness of healthy, but poorly conditioned subjects [13]. One need to take into account that persons with existing LBP might choose more sedentary activity exposure while those with fewer back disorders might perform more intensive activities. Irrespective of physical activity exposure, low levels of muscular fitness have been suggested as a risk factor for LBP although until now, the evidence is weak and results contradictory [14–16, 19, 30, 31]. In studies reporting on trunk muscle capacity, static, isokinetic or dynamic endurance tests are used. For most types of tests, there is inconclusive evidence for a relation with back pain mainly due to the heterogeneity in effect measures and the lack of uniform definitions of back pain [32]. We used dynamic endurance tests based on the idea

Table 2 Uni- and multivariate analysis of levels and dimensions of physical activity, physical fitness and low back pain

	MET-hours[a]	Current low back pain (quartiles)		
		Univariate analysis		Multivariate analysis[b]
		NRS < 4 ($n = 424$)	NRS ≥ 4 ($n = 240$)	NRS ≥ 4
Muscular fitness[c]				
OR (95% CI)[d]	1	1.00	1.00	1.00
	2	1.09 (0.79–1.51)	0.86 (0.59–1.25)	0.95 (0.64–1.40)
	3	0.81 (0.58–1.13)	0.54 (0.36–0.81)*	0.63 (0.42–0.97)*
	4	0.86 (0.62–1.20)	0.47 (0.31–0.71)**	0.54 (0.34–0.86)**
Aerobic fitness[e]				
OR (95% CI)[d]	1	1.00	1.00	1.00
	2	0.92 (0.66–1.27)	0.50 (0.33–0.75)**	0.58 (0.38–0.89)*
	3	0.81 (0.57–1.15)	0.63 (0.42–0.96)*	0.75 (0.48–1.17)
	4	0.93 (0.64–1.35)	0.45 (0.28–0.73)**	0.59 (0.35–0.99)
Total activity pattern				
OR (95% CI)[d]	1	1.00	1.00	1.00
	2	1.24 (0.89–1.72)	1.60 (1.07–2.40)*	1.52 (1.00–2.31)*
	3	1.12 (0.81–1.54)	0.98 (0.64–1.50)	1.06 (0.69–1.64)
	4	1.24 (0.90–1.72)	1.50 (1.00–2.25)*	1.60 (1.05–2.44)*
Total activity pattern (high intensity)[f]				
OR (95% CI)[d]	1	1.00	1.00	
	2	1.13 (0.74–1.72)	1.02 (0.61–1.69)	
	3	1.29 (0.96–1.73)	0.89 (0.62–1.29)	
	4	1.20 (0.89–1.48)	0.78 (0.54–1.14)	
Total activity pattern (moderate intensity)[g]				
OR (95% CI)[d]	1	1.00	1.00	
	2	0.99 (0.72–1.37)	0.89 (0.59–1.34)	
	3	0.83 (0.60–1.14)	0.86 (0.58–1.28)	
	4	1.10 (0.80–1.50)	1.12 (0.76–1.64)	
Total activity pattern (low intensity)[h]				
OR (95% CI)[d]	1	1.00	1.00	
	2	1.04 (0.76–1.42)	1.05 (0.70–1.58)	
	3	1.02 (0.74–1.42)	0.99 (0.65–1.52)	
	4	1.10 (0.80–1.51)	1.47 (1.00–2.16)*	
Transport (walking and bicycling)				
OR (95% CI)[d]	1	1.00	1.00	
	2	0.79 (0.50–1.24)	0.61 (0.33–1.12)	
	3	0.90 (0.67–1.20)	0.63 (0.43–0.92)*	
	4	0.92 (0.69–1.23)	0.99 (0.70–1.40)	
Domestic activities				
OR (95% CI)[d]	1	1.00	1.00	
	2	1.27 (0.92–1.75)	1.20 (0.78–1.84)	
	3	1.15 (0.83–1.59)	1.57 (1.05–2.36)*	
	4	1.22 (0.87–1.72)	1.54 (1.00–2.37)*	
Occupational activities				
OR (95% CI)[d]	1	1.00	1.00	
	2	1.31 (0.89–1.92)	1.16 (0.73–1.87)	
	3	1.35 (1.02–1.78)*	1.19 (0.85–1.67)	
	4	1.02 (0.70–1.41)	0.72 (0.47–1.10)	

Table 2 continued

	MET-hours[a]	Current low back pain (quartiles)		
		Univariate analysis		Multivariate analysis[b]
		NRS < 4 ($n = 424$)	NRS ≥ 4 ($n = 240$)	NRS ≥ 4
Gardening and hobbies				
OR (95% CI)[d]	1	1.00	1.00	
	2	1.21 (0.85–1.73)	1.38 (0.87–2.19)	
	3	0.98 (0.72–1.34)	1.20 (0.80–1.79)	
	4	1.06 (0.77–1.46)	1.78 (1.21–2.62)*	
Leisure time (walking and bicycling)				
OR (95% CI)[d]	1	1.00	1.00	
	2	1.03 (0.75–1.43)	0.81 (0.54–1.22)	
	3	1.17 (0.85–1.62)	0.86 (0.57–1.30)	
	4	1.08 (0.78–1.51)	1.14 (0.77–1.68)	
Sport activities				
OR (95% CI)[d]	1	1.00	1.00	
	2	1.15 (0.83–1.59)	1.02 (0.69–1.50)	
	3	1.16 (0.83–1.61)	0.98 (0.66–1.47)	
	4	1.22 (0.87–1.70)	0.95 (0.62–1.44)	

CI confidence interval, *NRS* numeric rating scale, *OR* odds ratio

[a] Volume of physical activity in metabolic equivalent value × (h/week)

[b] Multivariate analysis: total activity pattern/muscular fitness/aerobic fitness

[c] Summation of scores of the dynamic endurance capacity of abdominal, back and lower extremity extensor muscles

[d] Adjusted for age and gender

[e] Peak oxygen uptake (ml/kg/min)

[f] Physical activity intensity > 6.5 METs

[g] Physical activity intensity between 4 and 6.5 METs

[h] Physical activity intensity < 4 METs

* $P \leq 0.05$, ** $P \leq 0.01$

that generic human functioning is characterized by this type of locomotion.

Some limitations should be taken into account while interpreting our preliminary findings. The main objective of this study was the exploration of the relationship between physical activity, muscular and cardio-respiratory fitness, and LBP. Studying (habitual) physical activity and its associations demands an accurate reflection of activity behavior and energy expenditure. Subjective interpretation of the questions, LBP beliefs [33] and perception of the activity behavior can result in subjects either underestimating [34] or overestimating [35, 36] their levels of physical activity. In general, people tend to overreport physical activity and underestimate sedentary pursuits such as watching television [37]. It is known that, although LBP patients state they are moderately or severely disabled and less active, they still perform activities on a rather normal level [9, 10]. Moreover, the use of an energy costs table converts reported activities into approximate estimates of the rate of energy expenditure, i.e. the intensity of metabolic activity relative to resting conditions (METs) or an oxygen consumption (ml/min/kg). However, there are substantial inter-individual and intra-individual variations in the energy cost of various activities depending on the subject's age, gender, body mass, skill and level of fatigue and genetic contribution [6, 12]. We used self-reported physical activity data by means of the SQUASH [26]. The quality of questionnaire measurement of physical activity is in general limited due to several factors including recall bias and that daily physical activity is difficult human behavior to measure. Physical activity may consists of very different elements—type of activity, intensity, duration, frequency, performance—which also can vary highly during the day, week, month or period of life. The measurement of PA in large-scale studies is therefore highly challenged. The SQUASH has been shown to be reproducible and reasonably valid [27], which is true for most questionnaire-base measurement of physical activity [38]. More objective assessment of physical activity through the use of activity monitors such as pedometers, accelerometers and heart rate monitoring should always be considered in studies such as these but were not feasible in the UP-LIFT study.

Measuring LBP is also limited. In general, pain intensity is influenced by expectations, attitudes, and beliefs. Pain is rarely caused by psychological factors but is associated with psychological and emotional effects, such as fear, anxiety, and depression [39]. We used a numeric rating scale in measuring pain and defined pain rating $\geq$4 as functional limiting back pain. We considered a pain rating interfering with functioning from out a clinical point of view important and therefore we used it as the cut-off point for stratification. We believe that our strategy for this stratification of back pain is well supported by the available literature and clinical experience. Although a generically accepted framework to classify LBP in severity or functional consequences is still lacking, functional impairment has been used previously many times to classify pain severity [25, 40–42].

Finally, at first sight (or thought) workers of the police force are thought to be very different with respect to daily physical activity, but this is not the case. Activity patterns of workers of the police force do hardly differ from activity patterns form the general population, supporting the generalizability of study outcomes [5].

Our analyses show that higher fitness performances, being the outcome of our controlled testing procedure, are more strongly associated with less low back pain compared the levels of PA performances as assessed by self-reported questionnaires. This may suggest that for the prevention of low back pain physical activity of such intensity and duration that it contributes to fitness is important.

Conflict of interest None.

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