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# Impact of cardiovascular fitness and physical activity level on health outcomes in older persons

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**Abstract**

It remains unclear whether health recommendations should focus on improving cardiovascular fitness or physical activity energy expenditure in older persons. Although the literature is not abundant in this area, we first examined the association between cardiovascular fitness and physical activity. It appears that cross-sectional studies support a positive association between cardiovascular fitness and physical activity energy expenditure, whereas intervention studies suggest that when aerobic exercise is implemented later in life, older individuals either do not change or decrease physical activity energy expenditure outside of the program. We also considered the impact of improvements in cardiovascular fitness and physical activity on some commonly measured health outcomes in older persons. Based on preliminary studies, it appears that improving cardiovascular fitness has a greater impact on various health outcomes, whereas increased physical activity is also associated with health benefits, although to a lesser extent. Further work should be devoted at elucidating the individual benefits of increasing cardiovascular fitness or physical activity on health outcomes in older persons. Such information will be useful in refining exercise prescription to improve health status, particularly in older persons.



*Keywords:* Aging; Cardiovascular diseases; Exercise

## 1. Introduction

It is widely advocated that regular participation in aerobic activities is beneficial for improving many health outcomes in older persons. Participation in aerobic physical activity, among its many physiological effects, impacts on two major outcomes: (1) it increases energy expenditure and (2) it potentially improves cardiovascular fitness. Both of these outcomes are associated with a lower incidence of obesity, a lower risk for cardiovascular diseases and type II diabetes (Stofan et al., 1998; Blair et al., 1992). However, it is unclear whether health-related benefits are due to enhanced cardiovascular fitness or the increased physical activity energy expenditure.

It is generally believed that the phenotypes of physical activity levels and cardiovascular fitness are closely related in elderly. That is, it is commonly believed that individuals who are physically active also display a higher cardiovascular fitness. Therefore, the potential difference between these two concepts and their impact on health outcomes have been mostly overlooked. However, as suggested in the present review, the nature of the relationship between physical activity level and cardiovascular fitness in older individuals is complex as changes in physical activity energy expenditure and cardiovascular fitness following an aerobic exercise program may not be consistent or always in the same direction. Moreover, the effects of these two concepts on various health outcomes may differ widely. For example, a higher cardiovascular fitness may be beneficial to prevent cardiovascular diseases, whereas greater physi-

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Table 1
Description and reliability of different methods to measure physical activity energy expenditure (Starling et al., 1999)

| Method | Description and reliability |
|---|---|
| Age-neutral questionnaires | Questions asked by a trained interviewer; Usually asks for a recall of activities during a variable period of time (4 weeks to 12 months); Age-neutral questionnaires mostly focus on sport activities or high intensity activities that elderly individuals are unlikely to participate in; Accurate recall of activities can be difficult in aged people; Was shown to usually underestimate physical activity energy expenditure in older adults; Indirect measure. |
| Questionnaires for elderly | Questions asked by a trained interviewer; Based on a typical week, which may decrease chances of memory errors; Focuses on low to high intensity activities engaged in by older individuals; Was shown to accurately reflect direct measures in large cohorts, not in small groups; Indirect measure. |
| Accelerometer/pedometer | Counts the quantity of movements during a certain period of time which is then translated into a total activity energy count per day; Was shown to underestimate physical activity energy expenditure in older individuals; Loses its sensitivity to measure activities in a more active group; Unable to measure a variety of non-walking activities and does not detect motion in vertical plane; Does not measure post-exercise energy expenditure; Indirect measure. |
| DLW | Uses stable isotope enrichment disappearance to measure $CO_2$ production on a period between 7 and 14 days; Considered a 'gold standard' for validating other methods of physical activity energy expenditure in free-living individuals; Direct measure. |

cal activity energy expenditure may favor body weight regulation.

To our knowledge, few studies have addressed the independent effects of physical activity energy expenditure vs. improvements in cardiovascular fitness on health-related benefits. This scientific question has been a difficult area to examine as methodological limitations and differences in experimental designs have been the primary impediments to achieving a better understanding of these issues. Thus, we have attempted to clarify: (1) the percentage of shared variance between cardiovascular fitness and physical activity energy expenditure, (2) the direction of aerobic exercise-induced alterations in daily physical activity energy expenditure and cardiovascular fitness, and (3) the impact of changes in physical activity and cardiovascular fitness on several health-related outcomes in older persons.

## 2. Characteristics of cardiovascular fitness and physical activity

Cardiovascular fitness ($VO_2$max) represents the maximum capacity to perform physical work. Physiologically, it is defined as the maximal (or peak) oxygen capacity measured during a strenuous exercise effort and is mostly determined by physical activity participation and genetic contributors (Bouchard et al., 1998). Cardiovascular fitness can be directly measured and accurately quantified (ml kg/min) with a treadmill or ergometer test to exhaustion.

On the other hand, physical activity energy expenditure consists of the energy expended above resting metabolic rate and feeding-induced thermogenesis. It includes energy expenditure from fidgeting to intense sport activities including a large component of day-to-day physical activities. Physical activity energy expenditure is also determined by both a behavioral component as individuals can choose to be more or less physically active and a physiological component that is associated with the direct energy cost of activities and the physical capacity to perform these activities. It has also been shown that genetics contributes to the variability of physical activity energy expenditure (Pérusse et al., 1989). Several methods have been used to measure physical activity energy expenditure. These methods vary in sophistication, accuracy and cost. For instance, various questionnaires have been widely used as indirect and inexpensive methods for measuring physical activity energy expenditure. On the other hand, doubly labelled water (DLW) is considered the state-of-the-art method to measure the same variable, but its use is less common mainly because it is very expensive and labor intensive (Table 1).

## 3. Cardiovascular fitness and physical activity level: the nature of their association

Physical activity energy expenditure and cardiovascular fitness are both known to decline with advancing age. These declines are variable among individuals but we and others have shown that older individuals present a lower cardiovascular fitness than younger individuals with differences ranging between 12 and 30% (McGuire et al., 2001). This decline parallels the decline in physical activity energy expenditure in elderly. It has been suggested that physical activity levels in older individuals are approximately one third of the values measured at a younger age (Westerterp, 2000).

One may intuitively suggest that increased cardiovascular fitness leads to an increased physical activity energy expenditure and vice-and-versa. In fact, performing a given physical activity requires a smaller relative portion of the maximal oxygen capacity for an aerobically fit compared to an unfit individual. It is thus largely believed that individuals with higher levels of cardiovascular fitness should be more capable and willing to perform daily activities than their unfit counterparts hence, increasing their overall physical activity energy expenditure (Hunter et al., 2000). On the other hand, regular physical activity is also known to enhance cardiovascular fitness (Starling et al., 1998). However, some differences (behavioral vs. physiological) also characterize the phenotypes of cardiovascular fitness and physical activity (as discussed in the previous section) and we suggest that their relationship is not straightforward as shown by intervention studies. In this regard, the magnitude of the shared variance between cardiovascular fitness and physical activity may indicate if these two variables influence health outcomes in an independent manner. For that purpose, we surveyed the few studies that have examined the statistical relationship between physical activity level and cardiovascular fitness, using different methodologies and experimental designs.

### 3.1. Cross-sectional studies

#### 3.1.1. Physical activity energy expenditure measured by questionnaire

One report (MacAuley et al., 1998) examined the relationship between estimated peak oxygen capacity (cardiovascular fitness) and physical activity level by grouping subjects (aged 16 years and older) into groups 0–5 based on the number of occasions they performed moderate or vigorous physical activity in the previous 4 weeks. Group 0 performed no moderate or vigorous physical activity during the previous 4 weeks, whereas Group 5 performed 12 or more occasions of physical activity during the previous 4 weeks. Cardiovascular fitness was compared between groups 0–5 by the use of an ANOVA. These investigators found a significant difference between groups 0 vs. 5 for estimated cardiovascular fitness ($P < 0.001$) but not between any other groups. The authors concluded that in males, a large difference in activity level (from very low to high level) significantly impacts on cardiovascular fitness but that these differences are more difficult to detect at moderate levels of physical activity.

Another group studied this issue by examining the correlations between the quantity of leisure time physical activity of various intensities during the previous year (Minnesota Leisure Time Activity Questionnaire) (Taylor et al., 1978) and estimated peak oxygen capacity in individuals aged between 18 and 59 years old (Tuero et al., 2001). They observed that the amount of high intensity activities performed was significantly correlated with cardiovascular fitness ($r = 0.59$; $P < 0.001$). On the other hand, light ($r = -0.12$) and moderate ($r = 0.16$) activities did not significantly correlate with cardiovascular fitness. These results suggest that higher intensity physical activities are related to a greater peak oxygen capacity.

To our knowledge, only two reports examined the relation between cardiovascular fitness and physical activity energy expenditure in elderly individuals. Kostka et al. (1997) directly measured peak oxygen capacity and leisure time sports activities (Questionnaire d'Activité Physique St-Etienne) (Berthouze et al., 1993) in elderly women aged between 66 and 82 years of age. They found a significant correlation between cardiovascular fitness and sport activities ($r = 0.76$; $P < 0.001$). This study did not directly consider the intensity of exercise but it can be speculated that 'sports activities' implied activities of moderate to high intensity. This study suggests a high degree of concordance between cardiovascular fitness and higher intensity sport activities.

In their paper (Starling et al., 1998) measured peak oxygen capacity and leisure time physical activity using the Minnesota Leisure Time Activity Questionnaire (Taylor et al., 1978) in 99 older individuals (56–90 years old). They found a significant correlation ($r = 0.43$; $P < 0.05$) between cardiovascular fitness and leisure time physical activity. They also examined the correlation between cardiovascular fitness and physical activity adjusted for body composition and observed a milder but significant association ($r = 0.31$; $P < 0.05$). This is an important point since a portion of the shared variance between cardiovascular fitness and physical activity energy expenditure may be due to the effect of body weight and composition on energy metabolism and oxygen uptake.

Cross-sectional studies that measured physical activity using a questionnaire thus support a significant association between cardiovascular fitness and physical activity level. However, this association seems more evident for higher levels of physical activities whereas it is still unclear if there is such an association for lower levels of physical activity.

#### 3.1.2. Physical activity measured by doubly labelled water

Few studies have examined the association between cardiovascular fitness and physical activity directly measured using DLW. DLW measures total energy expenditure. Physical activity energy expenditure is obtained by subtracting resting energy expenditure and thermic-effect of food from total energy expenditure.

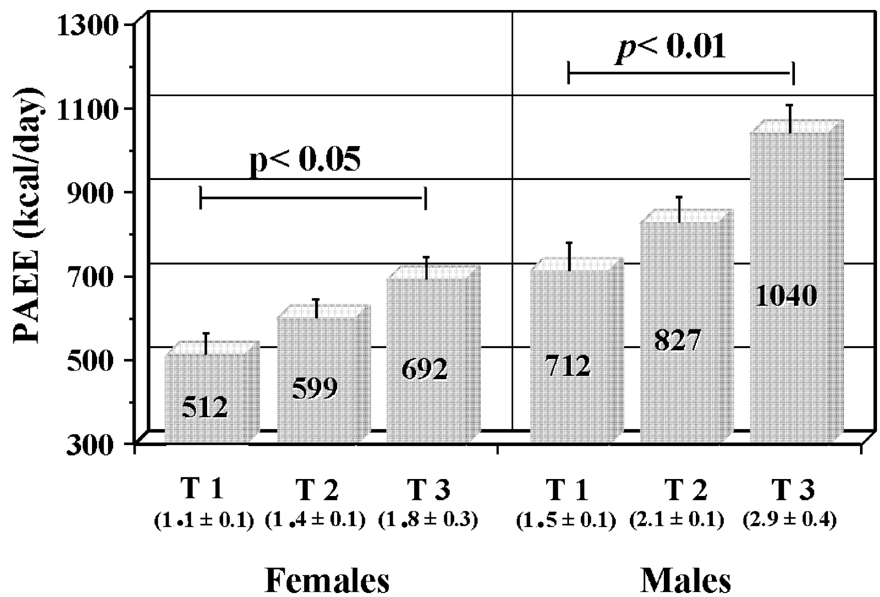


Fig. 1. Physical activity energy expenditure in men and women displaying low (T1), moderate (T2) and high (T3) cardiovascular fitness. $T$ = tertile of cardiovascular fitness; l/min. From Brochu et al. (1999).

Thus, it is important to note that using this technique, physical activity energy expenditure is a derived variable.

We investigated this question by using both DLW and a questionnaire (Minnesota Leisure Time Physical Activity Questionnaire) (Taylor et al., 1978) to measure physical activity energy expenditure in 84 men and 96 women aged between 45 and 90 years old (women: $66 \pm 8$ years; men: $67 \pm 8$ years) (Brochu et al., 1999). Results showed a significant correlation between peak oxygen capacity and physical activity energy expenditure DLW in both males ($r = 0.42$; $P < 0.0001$) and females ($r = 0.24$; $P < 0.05$). This same study showed that leisure time physical activity (questionnaire) was also correlated, to a lower level, with cardiovascular fitness in men ($r = 0.25$; $P < 0.05$) and women ($r = 0.25$; $P < 0.05$). Interestingly, investigators also examined the possibility of a threshold effect of peak oxygen capacity on physical activity energy expenditure. Subjects were categorized into three groups based on their measured peak oxygen capacity to examine whether a higher level of peak oxygen capacity impacts on physical activity energy expenditure, as measured from DLW. They found that in both men and women, the highest cardiovascular fitness group showed greater physical activity level than individuals with low cardiovascular fitness (males $P < 0.01$; females $P < 0.05$) (Fig. 1). They concluded that there was a positive association between higher levels of cardiovascular fitness and greater free-living physical activity energy expenditure in older individuals. Again, it seems that only at the high and low levels of cardiovascular fitness, can one detect a difference in physical activity energy expenditure.

In another study conducted in our laboratory (Dvorak et al., 2000), cardiovascular fitness and physical activity DLW were measured in 53 older men ($68 \pm 9$ years old) and 63 older women ($67 \pm 7$ years old). We observed a low order but significant correlation between peak oxygen capacity and physical activity energy expenditure (genders combined: $r = 0.37$; $P < 0.01$). This study demonstrates that cardiovascular fitness is also significantly correlated to physical activity energy expenditure measured by DLW in a population comprising exclusively older individuals but this relationship is modest.

Collectively, cross-sectional studies that measured physical activity using a questionnaire or DLW support a positive association between high levels of physical activity and cardiovascular fitness. However, the shared variance (6–58%) is rather modest.

### *3.2. Intervention studies*

Cross-sectional studies using correlational approaches provide the degree of importance of an association between two variables. However, it does not provide information on whether changes in cardiovascular fitness impact on physical activity levels. To address this issue, intervention studies are required. However, few studies have focused on aerobic exercise interventions aimed at increasing cardiovascular fitness and its impact on overall physical activity energy expenditure.

A study by Smolander et al. (2000) was conducted in a group of 80 men and women aged 35–60 years. They examined the effect of a combined aerobic and resistance exercise program (6 months) on changes in cardiovascular fitness and physical activity level (accelerometer) using a randomized controlled trial. They found that during the program, peak oxygen capacity and daily physical activity energy expenditure increased by 3.4 and 4.2%, respectively.

Our laboratory submitted a group of older men and women (56–78 years of age) to a 2 months endurance-training program and measured physical activity energy expenditure using DLW (1992). This study demonstrated that older individuals increased their cardiovascular fitness (9%) but concomitantly showed a decrease in daily physical activity energy expenditure (62%) during the training program. These results suggest that older individuals submitted to an aerobic training program may display a compensatory reduction in physical activity energy expenditure outside of the exercise program. Interestingly, this compensatory decrease occurred despite an improvement in cardiovascular fitness. This was the first study to suggest dissociation between cardiovascular fitness and physical activity energy expenditure in older persons.

Accordingly, another study (1998) submitted 13 older men and women ($62.8 \pm 2.3$ years old) to a progressive 14-week endurance-training program. Physical activity energy expenditure was assessed using a 7-day physical activity record at the beginning and at the end of the training program. Physical activity energy expenditure decreased by $7.7 \pm 8.6\%$ at the end of the endurance-training program. No data, however, were provided on cardiovascular fitness. These results also support a compensatory decrease in physical activity outside of the aerobic exercise program.

Collectively, these studies suggest that aerobic exercise intervention, especially when implemented at a later stage of life, increases cardiovascular fitness. This is in accordance with what was reported by Oja (2001) who reviewed a number of studies pertaining to the dose response between total volume of physical activity and indexes of fitness. However, aerobic exercise intervention seems to have little or no beneficial impact on daily physical activity energy expenditure outside of the program. In fact, physical activity energy expenditure outside of the endurance program appears to show a compensatory decrease in some instances. Behavioral modification may be needed to help elderly maintain their daily physical activity energy expenditure when participating in an endurance exercise program.

## 4. Understanding the paradox

It appears that depending on the type of experimental design, results may vary among studies. Cross-sectional studies generally support a positive association between physical activity level and cardiovascular fitness with correlations ranging from 0.25 to 0.76 (Starling et al., 1998; MacAuley et al., 1998; Tuero et al., 2001; Kostka et al., 1997; Brochu et al., 1999; Dvorak et al., 2000). The association is even stronger for higher intensity physical activity, suggesting that a high physical activity volume (frequency, duration and intensity) is reflected in a high cardiovascular fitness whereas the association between a moderate peak oxygen capacity and physical activity levels is weaker. In contradiction, except for the study of Smolander et al. (2000) that was partly conducted in a younger population, intervention studies appear to demonstrate that chronic endurance-training has little or no effect or may even decrease daily physical energy expenditure in older adults (Goran and Poehlman, 1992; Morio et al., 1998) outside of the exercise program. One can speculate that sedentary older individuals tend to reduce their usual daily physical activities partly because of the fatigue induced by aerobic exercise training. Moreover, it is possible that elderly individual replace their usual unstructured activities by the structured aerobic exercise session. This reinforces the possible need for behavioral intervention in combination with aerobic exercise intervention to enhance overall daily energy expenditure.

We interpret these results to suggest that long-term participation in physical activity, particularly of an intense nature, increases cardiovascular fitness as proposed by the moderate association between physical activity energy expenditure and fitness in cross-sectional studies. On the other hand, intervention studies show that short-term endurance exercise training appears to exert little or no effect on daily physical activity energy expenditure, despite significant increases in cardiovascular fitness. It thus seems that endurance exercise training may impact on the physiological aspect (cardiovascular fitness) but not on the behavioral aspect of physical activity. In other words, the results do not support the hypothesis that individuals displaying a greater cardiovascular fitness are more willing to perform daily activities, especially when the aerobic exercise program is implemented later in life. Behavioral interventions (suggestions on how to maintain or even increase day-to-day physical activity) may be needed in addition to endurance-training to impact on daily physical activity energy expenditure.

## 5. Clinical implications

Physical activity and cardiovascular fitness may interact in a unique and independent manner to influence health outcomes in the elderly. Thus, from a public health perspective, is it unclear if emphasis should be put on improving cardiovascular fitness or increasing daily physical activity energy expenditure, particularly in older persons. A few recent review articles have addressed this issue. Williams (2001) conducted a meta-analysis study by reviewing studies that measured the relative risk for CVD and CHD with respect to physical fitness and physical activity level. He reported that the risk for CHD and CVD decreased linearly in association with increasing levels of physical activity. Also, the risk for CHD and CVD decreased linearly in association with increasing cardiovascular fitness but there was a precipitous decline of the risk for CHD and CVD in the first 25th percentile of cardiovascular fitness that did not appear in physical activity. Moreover, the relative risk reduction was significantly greater for cardiovascular fitness than physical activity level at all levels. Based on these observations, it appears that cardiovascular fitness might have a greater impact on reducing risk for CHD and CVD compared to physical activity.

Blair et al. (2001) reviewed a series of studies that measured morbidity from major chronic diseases (CHD, stroke, CVD, cancer, etc.) as well as all-cause mortality rate (cancer, CVD, etc.). They observed that all studies showed an inverse gradient across cardiovascular fitness categories for the risk of morbidity. Moreover, most studies showed an inverse relation across physical activity categories for the risk of morbidity. The same review presented preliminary results from the Aerobic Center Longitudinal Study examining mortality in a multivariate analysis using cardiovascular fitness and physical activity level as covariates along with other confounding variables. In this case, the association between physical activity and health was no longer significant suggesting a more important effect of cardiovascular fitness on health-related outcomes. However, the authors cautioned the fact that cardiovascular fitness was measured objectively (peak oxygen capacity) but physical activity level was measured subjectively (self report), which may have lead to misclassification of physical activity levels that could have influence the outcome of the study.

The topic was also reviewed by Oja (2001), who evaluated studies for the possible dose response between the total volume of physical activity, fitness and various health measures like systolic blood pressure, total cholesterol., HDL, LDL, and triglycerides. The main conclusion of this paper was that there is only weak evidence for a dose response of the volume of activity performed during a week and health measures.

In a study conducted in our laboratory (2000), the effect of cardiovascular fitness vs. physical activity energy expenditure on selected cardiovascular disease factors was examined in older individuals. Investigators found that older individuals with higher levels of cardiovascular fitness, regardless of their physical activity level, showed lower levels of fasting insulin, triglycerides, total cholesterol, total cholesterol to HDL ratio, LDL, and waist circumference compared to individuals with a lower cardiovascular fitness. Moreover, individuals with a high cardiovascular fitness but low physical activity energy expenditure displayed a more favorable cardiovascular disease risk profile than individuals with low cardiovascular fitness and high physical activity energy expenditure. The main conclusion of that study was that higher levels of cardiovascular fitness have greater cardio protective effects than higher levels of physical activity energy expenditure in older individuals.

Another study (Foldvari et al., 2000) attempted to identify the physiologic factors most relevant to self-reported functional independence in the elderly population. It was reported that functional status was related to aerobic capacity and habitual physical activity level. However, leg press power and habitual physical activity level were the only two factors that contributed independently to functional status. This study suggests that leg power, which is likely to be the outcome of long-term history of physical activity and contributes to cardiovascular fitness, may underlie the relationship between cardiovascular fitness and functional status.

Finally, one study evaluated the relationship of activity and fitness on the prevalence of functional limitations (Huang et al., 1998). They showed that although both cardiovascular fitness and physical activity were related to the prevalence of functional limitations, the gradient was steeper for cardiovascular fitness than for physical activity.

Collectively, these studies suggest that cardiovascular fitness has a greater impact on various health outcomes than physical activity level, especially for health outcomes that pertain to cardiovascular health. However, as we suggested earlier, cardiovascular fitness is likely to be the outcome of a long history of higher levels of physical activity. Moreover, one study suggests that leg power may be more relevant to functional status than cardiovascular fitness. Collectively, these results raises the question of whether it is cardiovascular fitness or long-term high physical activity energy expenditure that is directly associated with these health benefits.

### *5.1. Exercise for patients with established coronary heart disease (secondary prevention)*

In middle-aged and older patients who have experienced a recent myocardial infarction, participation in regular aerobic exercise in a cardiac rehabilitation setting is associated with increased cardiovascular fitness and a 25% decrease in overall and cardiovascular mortality at 3 years (Oldridge et al., 1988; O'Connor et al., 1989). The mechanism may relate to improved coronary artery vasodilatory capacity which appears after only 6 weeks of fitness oriented training (Hambrecht et al., 2000). On the other hand, in a longitudinal study of 772 men over the age of 65 years with CHD, increased physical activity, in particular, walking for four or more hours per week, was also associated with a significant reduction in overall mortality (Wannamethee et al., 2000). Thus, both increased cardiovascular fitness and increased physical activity are associated with improved longevity in older CHD patients.

In older patients with CHD, other important outcomes of interest include measures of physical functioning, or disability, and mediators of coronary risk predictors such as obesity, and obesity-related risk factors which themselves predict cardiovascular outcomes. These include insulin resistance, type II diabetes, hypertension, hyperlipidemia and clotting abnormalities. Improvements in physical function in older CHD patients have been seen after short-term exercise conditioning studies of 3–4 months with interventions that included both aerobic and resistance training (Ades et al., 1999; Brochu et al., 2002). These interventions were not designed to markedly increase total physical activity energy expenditure. During the 3-month aerobic conditioning study which increased peak aerobic capacity by 16%, exercise-related caloric expenditure was measured to be quite low with older patients expending only 700 kcal/week during the formal exercise program (Ades et al., 1999; Savage et al., 2000).

When the outcome of interest is a decrease in measures of obesity, the training program may need to differ. We have found that both in middle-aged and older obese patients with CHD, improvements in fitness over a 3-month training period do not result in a significant reduction in measures of obesity, nor in obesity-related risk factors (Brochu et al., 2000). When the same 3-month exercise program was altered to maximize exercise-related caloric expenditure by focusing on longer distance, but less intensive daily walking, significant weight loss resulted, associated with decreases in total and intra-abdominal fat, improved lipid profiles and decreased fasting insulin levels (Savage et al., 2001).

Thus, in summary, the type of exercise to be recommended for older patients with CHD depends upon the clinical outcome of interest (Ades, 1999, 2001). Decreases in short-term mortality rates and improvements in measures of physical function appear to be associated with exercise regimens that increase peak aerobic fitness and/or strength. Decreases in overall mortality have also been shown to occur with exercise that increases total physical activity. Measures of obesity and obesity-related risk factors appear to improve primarily with an exercise protocol that maximizes total exercise-related caloric expenditure.

## 6. Future directions

The current review strongly suggests that although increased physical activity is associated with health benefits, improving cardiovascular fitness has a greater impact on various health outcomes. However, these conclusions are drawn from a small number of studies and further work is needed to help understand the individual impact of physical activity level and cardiovascular fitness on the health of older individuals. For instance, we mentioned that it is not clear if the relationship between cardiovascular fitness and lower risks for CVD is rather due to a long history of physical activity level (Table 2). Moreover, functional status may be associated with leg power, which is partly the outcome of a long history of participation in physical activity, instead of cardiovascular fitness. It is thus unclear if the focus should placed on increasing cardiovascular fitness (exercise intensity) or physical activity frequency and duration. Moreover, it would be important to better understand the impact of endurance exercise implemented at an older age on physical activity energy expenditure. The addition of behavioral intervention may be useful in increasing physical activity energy expenditure outside of the exercise program and the impact on various health outcomes should be better known. It is noteworthy that the present review did not address the impact of resistance exercise on physical activity level. Resistance training has been shown to favorably affect physical activity energy expenditure outside of the program (Hunter et al., 2000; Smolander et al., 2000; Nelson et al., 1994; Fiatarone et al., 1994). Thus, its combination with aerobic training may be useful to increase cardiovascular fitness and physical activity energy expenditure at the same time. Collectively, such information will be useful in refining exercise prescription to improve health status of older persons.

## 7. Conclusions

Both physical activity participation and cardiovascular fitness are undoubtedly associated with improved health status in older adults. However, the present review cites evidences that both components may not respond in a similar fashion to an exercise program implemented at a later stage of life. Few studies are available that have focussed on contrasting cardiovascular fitness and physical activity level for various health outcomes. Based on the body of evidence reported in the present review, it appears that improving cardiovascular fitness has a greater impact on various health outcomes including cardiovascular diseases and general mortality in the elderly population. On the other hand, physical activity is also associated with health benefits, although to a lesser extent. However, in order to improve the magnitude of benefits from exercise training, behavioral intervention may be needed to promote maintenance of day-to-day physical activity during an exercise program in elderly individuals.

Table 2
Summary of studies that examined the statistical relationship between cardiovascular fitness and physical activity level

| Authors (reference) | Methods | Results |
|---|---|---|
| *Physical activity measured by questionnaire* | | |
| MacAuley et al. (1998) | $n$: 449 men; 502 women age range: 16–74 years old<br>Subjects were grouped (0–5) based on the number of occasions they performed moderate or vigorous physical activity. Cardiovascular fitness was compared between groups. | Significant difference between groups 0 and 5 ($P < 0.0001$)<br>Conclusion: wide differences in activity level significantly impacts on cardiovascular fitness. |
| Tuero et al. (2001) | $n$: 44 men; 38 women age range: 18–59 years old<br>They examined the correlation between high intensity, moderate and light activities and peak oxygen capacity. | High intensity: $r = 0.59$ ($P < 0.001$)<br>Moderate: $r = 0.16$ (n.s.)<br>Light: $r = 0.12$ (n.s.)<br>Conclusion: higher intensity physical activities are related to a greater cardiovascular fitness. |
| Kostka et al. (1997) | $n$: 33 women age range: 65–84 years old<br>They examined the correlation between leisure time sport activities and cardiovascular fitness. | $r = 0.76$ ($P < 0.001$)<br>Conclusion: there is a high correlation between physical activity level and cardiovascular fitness in older women. |
| Starling et al. (1998) | $n$: 48 men; 51 women age range: 56–90 years old<br>They examined the correlation between leisure time sport activities and cardiovascular fitness. They also examined the correlation between leisure time sport activities and cardiovascular fitness when controlled for body composition. | $r = 0.43$ ($P < 0.05$)<br>CON: $r = 0.31$ ($P < 0.05$)<br>Conclusion: there is a significant correlation between physical activity level and cardiovascular fitness, even when controlled for body composition. |
| *Physical activity measured by DLW* | | |
| Brochu et al. (1999) | $n$: 84 men; 96 women age range: 45–90 years old<br>They examined the correlation between physical activity energy expenditure and cardiovascular fitness. They also examined the correlation between leisure time sport activities (questionnaire) and cardiovascular fitness. | DLW<br>Males: $r = 0.42$ ($P < 0.0001$)<br>Females: $r = 0.24$ ($P < 0.05$)<br>Questionnaire<br>Males: $r = 0.25$ ($P < 0.05$)<br>Females: $r = 0.25$ ($P < 0.05$)<br>Conclusion: there is a positive association between cardiovascular fitness and physical activity energy expenditure, regardless of the methodology used. |
| Dvorak et al. (2000) | $n$: 53 men; 63 women age range: 60 years and older<br>They examined the correlation between physical activity energy expenditure and cardiovascular fitness. | $r = 0.37$ ($P < 0.01$)<br>Conclusion: there is low order but significant correlation between cardiovascular fitness and physical activity energy expenditure. |

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