WHITE PAPER

Physical Inactivity and Health

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Executive Summary

Physical inactivity and low cardiorespiratory fitness are major public health problems, and contribute to a number of chronic health conditions. The acknowledgment of the many hazards associated with a sedentary lifestyle has led to public health recommendations for physical activity by a number of professional organizations. Physical activity can be differentiated from exercise in that physical activity is "any bodily movement" whereas exercise is a "subset of physical activity that is characterized by planned and purposeful training."[1] To be consistent with the current recommendations, this paper will use the term "physical activity."

Physical activity recommendations have changed throughout the past 40 years. Early recommendations focused on enhancing cardiorespiratory fitness and body composition, whereas more recent recommendations focus on the associated health benefits for the general population. The American College of Sports Medicine (ACSM) released the first position statement on physical activity recommendations in 1978, recommending that adults participate in rhythmical aerobic activity using large muscle groups 3–5 days per week, at 60–90% of maximal heart rate, for 15–60 minutes per session. Starting in the 1990's, compelling evidence emerged on the health benefits of less intense types of physical activity (i.e. moderate intensity), which led to the acknowledgement in subsequent statements that physical activity does not need to be vigorous to obtain health benefits.[2, 3]

In 1992, the American Heart Association recognized the value of moderate intensity physical activity and identified physical inactivity as the fourth major modifiable risk factor for cardiovascular disease (CVD).[4] In 1995, the ACSM and Centers for Disease Control

(CDC) released a public health recommendation for physical activity stating that "every American should accumulate 30 minutes of moderate intensity activity most, preferably all, days of the week."[5] This recommendation, which emphasized accumulation of physical activity, was aimed at the millions of sedentary adults responsible for a large amount of the public health burden of chronic diseases.[6] Other professional organizations have endorsed recommendations very similar to these,[7-9] and although fundamentally unchanged, clarifications to these recommendations were made in 2007.[10] In 2008, the first comprehensive Physical Activity Guidelines were released by the United States Federal Government. The Guidelines stated that for substantial health benefits, all adults should accumulate at least150 minutes of moderate intensity physical activity per week, 75 minutes of vigorous intensity activity, or a combination of moderate and vigorous activity.[11] The Physical Activity Guidelines, as well as the ACSM/CDC recommendations, acknowledge that greater health benefits can be obtained with higher levels of physical activity (beyond the basic recommendation).[5, 10, 11]

Recently, a comprehensive plan for promoting physical activity in the American population was released. The National Physical Activity Plan provides a framework to support a broad and comprehensive national effort to increase physical activity throughout the population. Background White Papers for the National Plan were also published in the *Journal of Physical Activity and Health*. These reports cover in more detail the eight sectors that are addressed in the National Plan, and can be accessed at (http://hk.humankinetics.com/JPAH/freearticles.cfm? custnum=87F48F2DCE1DDDDA&cprice=us). National plans have been undertaken with considerable success in other health domains. The current prevalence of and costs related to chronic disease, including obesity, make it dramatically evident that the time has come for the United States to implement a National Plan for Physical Activity as many other nations have already successfully done.

The purpose of this paper is to introduce the role of physical activity as part of positive health and to illustrate the importance of physical activity and cardiorespiratory fitness in promoting it. We will first define positive health, provide a brief background on how the field emerged, and describe how physical activity and fitness fit in to the field of positive health. Next, we will summarize the state of the inactivity and obesity epidemics in the United States, and propose a plausible explanation for the obesity epidemic. We will examine the fitness/fatness hypothesis; that is, which factor is more important for promoting health, preventing disease, and delaying mortality? Finally, the Positive Health Physical Activity Committee has performed secondary data analyses to address additional issues relating physical activity to Positive Health. Several papers are in review or in press.

Positive Health and Cardiorespiratory Fitness

Positive health is the empirical study of health assets. A "health asset" can be defined as a factor that produces better health, over and above risk factors for disease. Positive health builds on the research and application of the principles of positive psychology to issues of overall health. It focuses on promoting exceptional health and optimal well-being, not simply on the absence of disease and dysfunction. Positive health aims to ascertain which specific health assets produce longer life and higher health-related quality of life, and which health assets lower disease risk and health care costs. Seligman[12] postulates that positive health can be operationally defined by three classes of quantifiable independent variables (i.e. health assets), namely subjective, biological, and functional factors. One major functional component of positive health is cardiorespiratory fitness, which is an objective indication of recent physical activity habits.

The human body is remarkably adaptive to any situation or environment it is put in. The physiological systems of individuals who are regularly active adapt so that the body is more efficient and functional. The heart, lungs, and organs in fit individuals are able to consume, transport, and use oxygen more efficiently.

Cardiorespiratory fitness is directly related to health. At the most basic level, cardiorespiratory fitness is important for withstanding the strains of everyday life and managing the stresses of occasional emergencies. Research has also shown that cardiorespiratory fitness is strongly associated with the overall risk of morbidity and mortality. Fit individuals have been shown to have a substantially lower overall risk of incidence of cancer,[13] hypertension,[14, 15] metabolic syndrome,[16] type 2 diabetes,[17, 18] and cardiovascular disease,[19-21] and a lower risk of cancer,[13, 22-24] cardiovascular disease,[25-27] and all-cause[26-29] mortality. These relationships remain strong, even after controlling for a number of risk factors known to be associated with disease or death. For example, in a prospective study of 14,811 women followed for a mean of 16 years, the breast cancer mortality risk was 33% and 55% lower in moderately and high fit women compared to low fit women, after adjusting for BMI, smoking, drinking, chronic conditions, abnormal exercise ECG responses, family history of breast cancer, oral contraceptive use, and estrogen use.[24] (Figure 1)

Cardiorespiratory fitness was associated with all-cause mortality in a study of 10,224 men and 3,120 women followed for ~8 years.[30] After controlling for age, serum cholesterol level, blood pressure, smoking habit, fasting blood glucose level, family history of coronary heart disease, and length of follow-up, the relative risks of low cardiorespiratory fitness for all-cause mortality for each quintile of cardiorespiratory fitness (Q1-Q4) were 1.82 (Q1), 1.33 (Q2), 1.29 (Q3), 1.06 (Q4) for men and 3.92 (Q1), 3.01 (Q2), 2.06 (Q3), 1.55 (Q4) for women. Fortunately, research has shown that improving cardiorespiratory fitness over time can reduce the risk of death.[31] In other words, it is not "too late" for unfit individuals. In a prospective study of 9,777 men (mean time between examinations was 4.9 years), the highest age-adjusted all-cause mortality risk was for men who were unfit at both visits (referent) whereas men who were fit at both visits had the lowest risk of age-adjusted all-cause mortality (RR=0.33). Interestingly, men who were initially unfit and became fit had a 44% lower age-adjusted risk of all-cause mortality (RR=0.56) when compared with men who remained unfit. (Figure 2)

Cardiorespiratory fitness is one important functional health asset that can promote positive health. Fit individuals have a lower risk for a number of chronic diseases, as well as death. Fitness also promotes function and prevents loss of functional status.[32] Increasing cardiorespiratory fitness is a logical and realistic means of promoting optimal health and functioning; that is being in a state of health that is beyond the absence of disease and in a state of functioning that is beyond the absence of impairment. Efforts to improve population-wide fitness should continue, as being in a state of positive health will be a consequence.

FIGURE 1. Survival free of breast cancer across cardiorespiratory fitness (CRF) status

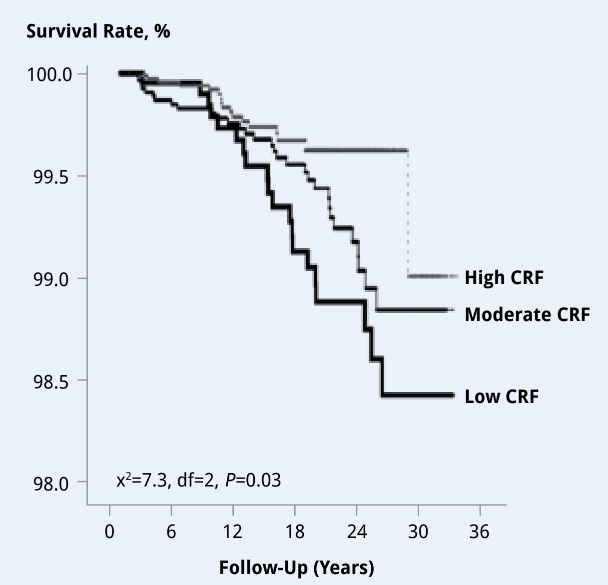
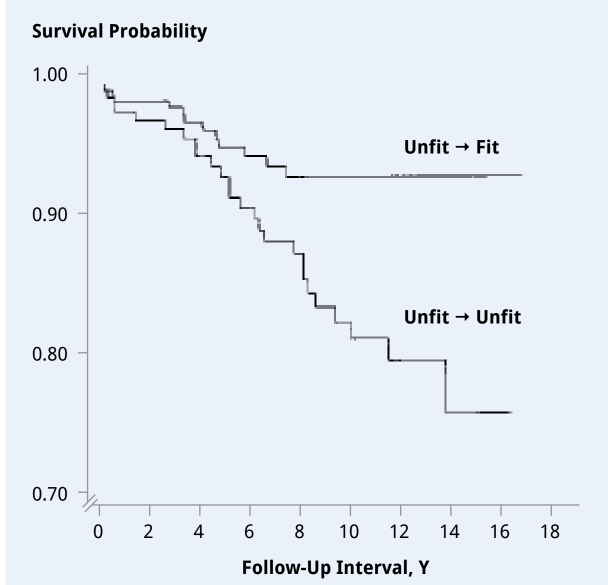


FIGURE 2. Survival curves for change or lack of change in physical fitness in men



INACTIVITY AND OBESITY IN THE UNITED STATES

THE REDUCTION IN OCCUPATIONAL ENERGY EXPENDITURE ACCOUNTS FOR NEARLY ALL OF THE OBSERVED INCREASE IN MEAN WEIGHT OVER THE LAST 5 DECADES IN THE UNITED STATES

Despite the well established benefits of regular physical activity (e.g. obesity prevention), far too many U.S. adults are sedentary and unfit. The development of evidence-based physical activity recommendations has not, unfortunately, resulted in significant changes in population-level physical activity behaviors, or subsequently, changes in the prevalence of overweight and obesity. National surveillance system data show that leisure time physical activity in the United States has remained relatively stable over the past couple of decades, even increasing in the more recent years (likely due in part to changes in the surveillance questions tracking these trends).[33-36] The prevalence of overweight and obesity seems to stabilizing, but still remains far too high.[37]

The causes of the ongoing obesity epidemic are not well established. Despite the great economic and health care significance of the obesity epidemic, relatively few longitudinal population-based data examine this issue. At the most basic level, weight is the end-product of energy consumed and energy expended. Physical activity is the only modifiable variable contributing to total energy expenditure and can be segmented into occupational (i.e., work-related), domestic, and non-occupational (i.e. leisure-time) physical activity.

A number of studies have suggested that increases in food intake is largely, if not completely, responsible for the obesity epidemic.[3-5] Although the relatively unchanged trends in leisure time physical activity in the past decades support the hypothesis of excessive caloric intake causing the obesity epidemic, it is likely not the only, or even the major, cause. Time spent in leisure-time physical activity represents a relatively small portion of the total hours in a week, and only one type of physical activity resulting in energy expenditure. Because time spent at work represents the largest segment of waking hours for most people, occupational physical activity may have an even greater impact on total energy expenditure. While a common assertion is that occupational physical activity has decreased in recent decades, studies have not examined this in detail, nor has the relationship between changes in occupational physical activity and changes in mean body weight or the prevalence of obesity been examined. [6] Using nationally representative data sources we examined trends in occupational physical activity during the past 5 decades and explored how these trends related to changes in mean body weight and the prevalence of obesity in the United States.

FIGURE 3. Service, goods producing and agriculture jobs in US, 1960–2008

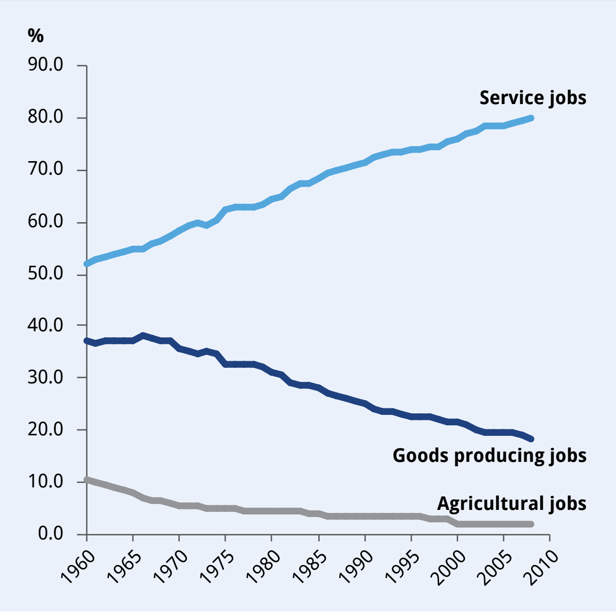


FIGURE 4. Goods producing jobs in the US, 1960–2008

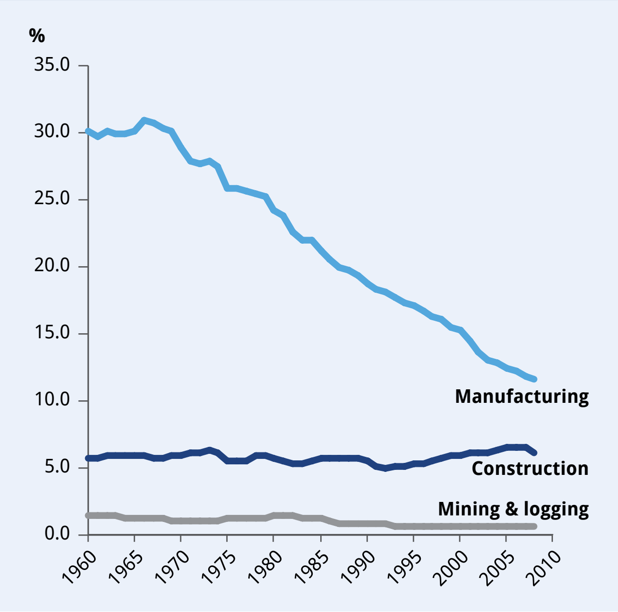
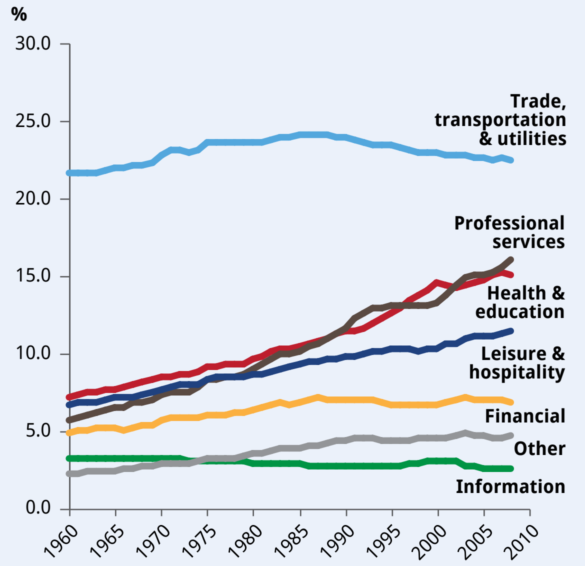


FIGURE 5. Service jobs in the US, 1960–2008



Employment data (nonagricultural industries) were derived from the Current Employment Statistics (CES) program whereas agricultural employment data were derived from the Current Population Survey (CPS). Occupations (nonagricultural) were broadly categorized as goods-producing or service providing. Goods-producing further sub-categorized into mining-logging, construction and manufacturing, while service-providing occupations are further divided into the categories of trade (wholesale and retail), transportation/utilities, information, financial services, professional/business services, education/health services, leisure/hospitality and other. The prevalence of service occupations, goods producing occupations and agricultural occupations for the U.S. from 1960 to 2008 are shown in Figure 3. There has been a decrease over the last 5 decades in both goods producing and agriculture occupations and a substantial increase in the prevalence of service occupations.

Within the goods producing occupations, construction has been relatively constant whereas the prevalence of manufacturing and mining/logging occupations has decreased. In the 1960's, more than 30% of U.S. private sector occupations were in manufacturing. This number has decreased to approximately 12% in 2008. (Figure 4)

In the service occupations category, there has been a decrease in the prevalence of information occupations, while the prevalence of all other service occupations has increased. The occupation categories of professional services, health/education and leisure/hospitality in particular have seen large increases. Together, these three service occupation categories made up approximately 20% of U.S. occupations in the early 1960's, and by the year 2008, they represented 43% of U.S. occupations. (Figure 5)

The estimated median and range of physical activity intensity (METs) as well as the estimated caloric expenditure of each occupation is shown in Table 1. Mining/ logging, construction, and manufacturing

TABLE 1. Estimated median and range of physical activity intensity (METs) as well as the estimated caloric expenditure of each occupation

	METs—Median (min, max)	Activity Category
Farm Jobs	3.0 (2.5, 4.5)	Moderate
Goods-Producing		
Mining and logging	3.8 (3.0, 8.0)	Moderate
Construction	4.0 (1.5, 7.5)	Moderate
Manufacturing	3.0 (1.5, 4.0)	Moderate
Service-Providing		
Trade (wholesale & retail), transportation, and utilities	2.0 (1.5, 3.0)	Light
Information	1.5 (1.5, 1.5)	Sedentary
Financial activities	1.5 (1.5, 1.5)	Sedentary
Professional and business services	1.5 (1.5, 2.0)	Sedentary
Education and health services	2.5 (1.5, 4.0)	Light
Leisure and hospitality	2.5 (1.5, 3.5)	Light
Other services	2.5 (1.5, 3.0)	Light

are considered moderate intensity activity occupations (3.0–5.9 METs). All service occupation sectors were classified as either sedentary (<2 METs) or light (2.0–2.9 METS) intensity activities.

Trends in the prevalence of sedentary, light, and moderate intensity occupations from 1960 to 2008 are shown in Figure 6. Although there was a steady increase in the prevalence of sedentary and light intensity physical activity occupations since

FIGURE 6. Trends in the prevalence of sedentary, light and moderate intensity occupations, 1960–2008

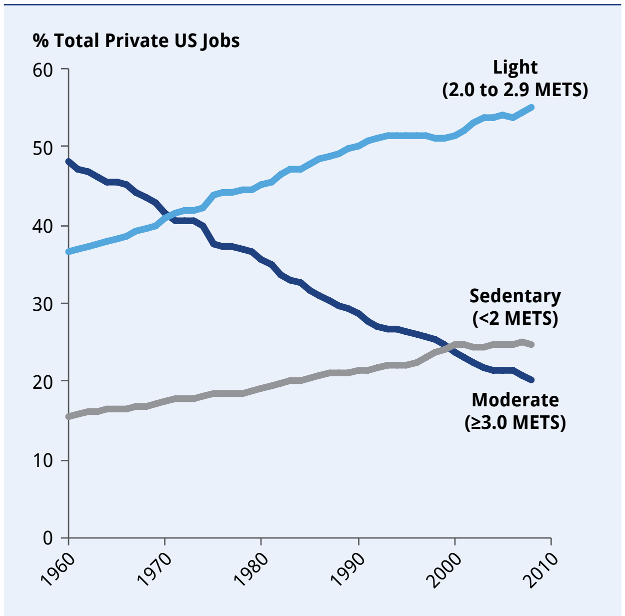


FIGURE 7. Ratio of sedentary and light intensity occupations to moderate intensity occupations in the US, 1960–2008

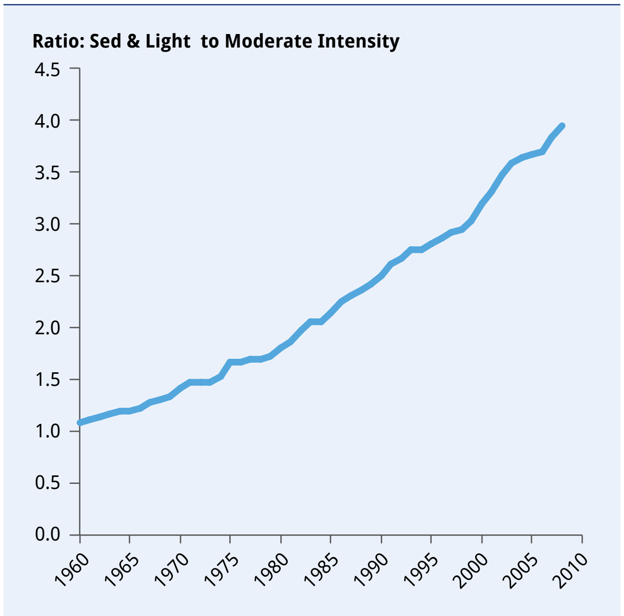


FIGURE 8. Ratio of sedentary and light intensity occupations to moderate intensity occupations verses the prevalence of obesity in the US

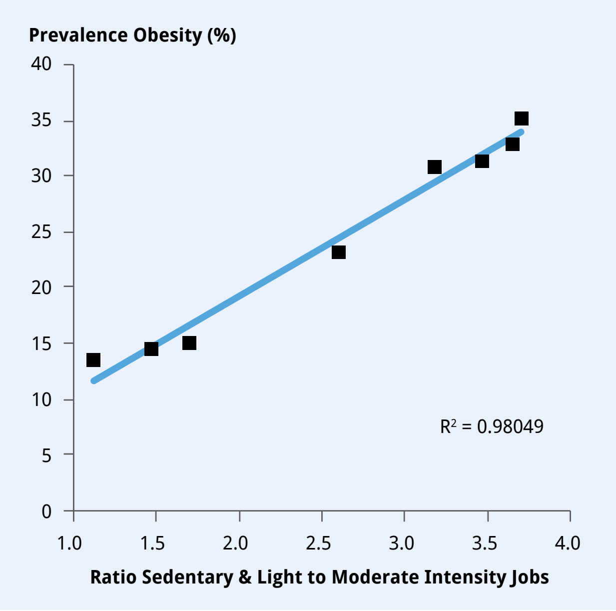


FIGURE 9. Occupation-related METs in the US, 1960–2008

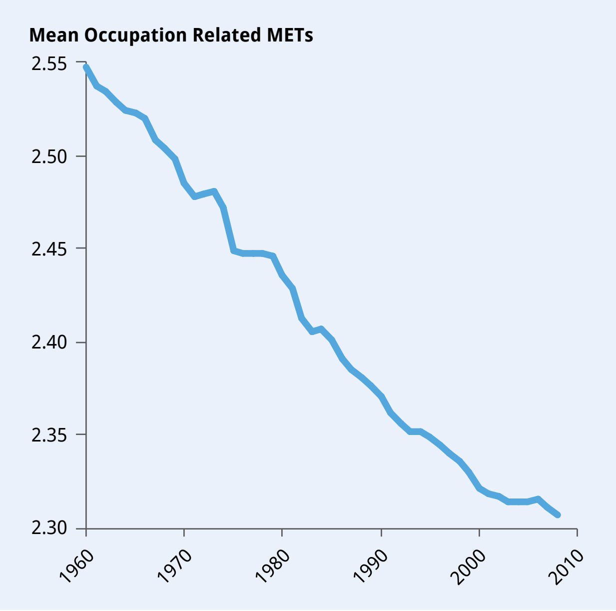


FIGURE 10. Occupation-related daily caloric expenditure in the US, 1960–2008

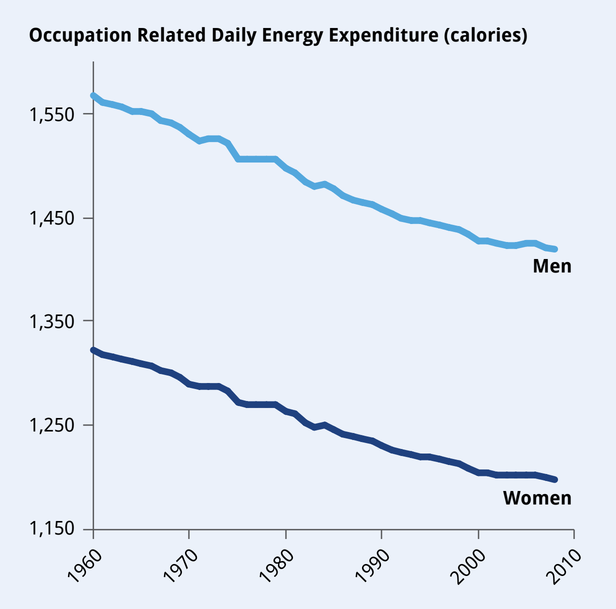


FIGURE 11. Predicted weights and NHANES weights for US men

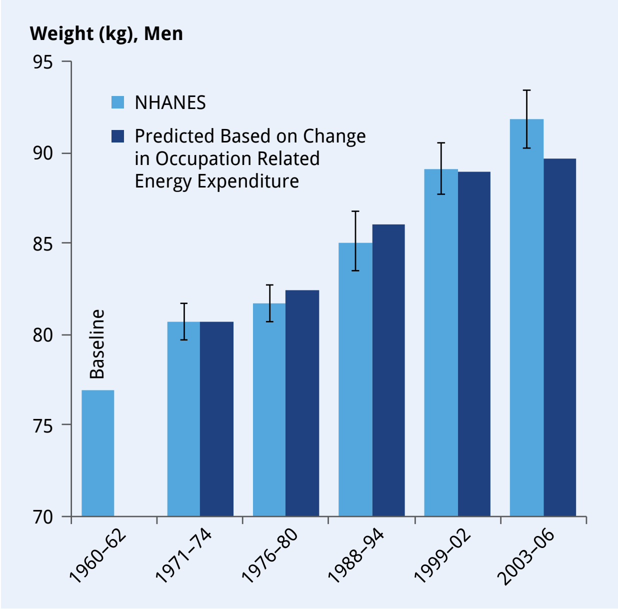
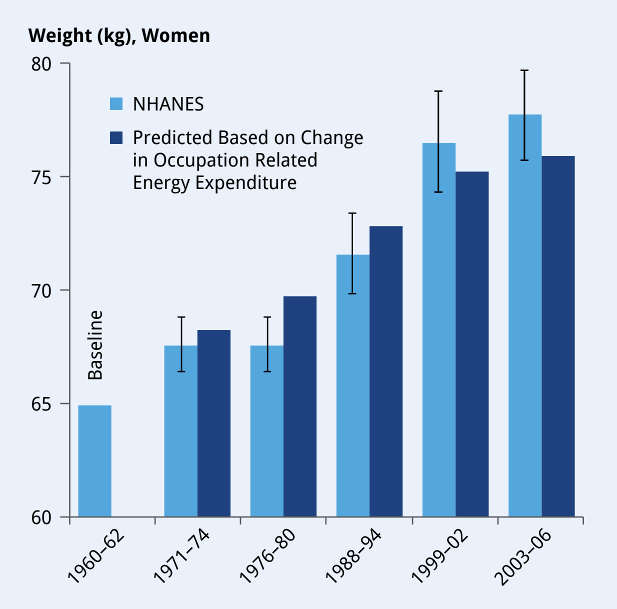


FIGURE 12. Predicted weights and NHANES weights for US women



1960, the prevalence of moderate intensity physical activity occupations has decreased from 48% in 1960 to 20% in 2008.

The ratio of sedentary and light intensity occupations to moderate intensity occupations since 1960 is shown in Figure 7. During the 1960's the ratio was just over 1.0 and by 2008 the ratio nearly quadrupled to 4.0.

The ratio of sedentary and light to moderate intensity occupations in the U.S. versus the prevalence of obesity (data derived from NHANES) for given years is shown in Figure 8. There was a strong association between the ratio of sedentary and light occupations to moderate intensity occupations and the prevalence of obesity (R^2= 0.91).

The mean occupation-related METs and the associated change in occupation-related daily caloric expenditure for women and men are shown in Figures 9 and 10. There was a steep decline in mean occupation-related METs, and consequently mean occupation-related physical activity energy expenditure from 1960 to 2008. From 1960 to 2008 there was an approximate drop in occupation-related daily energy expenditure of 140 calories for men and 124 calories for women. (Figures 11 and 12)

The energy balance model predicted weights based on change in occupation-related daily energy expenditure since 1960 for each NHANES examination period compared to the actual change in weight for 40-50 year old men and women is shown in Figure 11. The energy balance model assumed a 5 day work week. For both men and women the predicted weight based on changes in occupational energy expenditure closely matches the NHANES weight for each examination period.

DOES THE DECLINE IN OCCUPATIONAL PHYSICAL ACTIVITY EXPLAIN THE OBESITY EPIDEMIC?

Over the last 50 years, there has been a shift from occupations that require moderate intensity physical activity to occupations that are largely sedentary. In the early 1960's, almost half of private industry occupations in the United States required at least moderate intensity physical activity, and now less than 20% demand this level of activity. This shift from moderate intensity activity occupations to those requiring minimal activity is strongly associated with changes in the prevalence of obesity. Daily occupation-related energy expenditure has decreased by approximately 124 calories for women and 140 calories for men. Interestingly, the reduction in occupational energy expenditure accounts for nearly all of the observed increase in mean weight over the last 5 decades in the United States.

It is unlikely that there will be a return to occupations that demand moderate levels of physical activity. Therefore, from a public health perspective, and in order to increase positive health, it is important to promote physically active lifestyles outside of the work day. The approximate 124 calories per day for women and 140 calories per day for men reduction in occupation-related energy expenditure over the last 50 years would have been adequately compensated for by meeting the 2008 federal physical activity recommendations of 150 minutes per week of moderate intensity activity or 75 minutes per week of vigorous intensity activity.[13] While it is often noted that the prevalence of Americans who achieve this recommendation has been constant over recent decades, self-report data indicate that only 1 in 4 Americans achieve this level of physical activity.[18] Perhaps more disheartening, when physical activity is assessed objectively (i.e. accelerometers), the number of Americans achieving recommendations falls to 1 in 20.[19] Because energy expenditure has largely been removed from the work place, the relative importance of leisure-time physical activity has increased and should be a major focus of public health interventions and research.

Fitness vs. Fatness: Which Is More Important in Predicting Mortality?

In the past 15 years several studies have described the independent effects of cardiorespiratory fitness[30, 38-44] and fatness on mortality.[45-50] Studies have shown that being overweight or obese is associated with an increase in mortality in both men and women.[51] Similarly, cardiorespiratory fitness has also been shown to be a strong, inverse, independent risk factor for mortality.[52] Although the independent effects of fitness and fatness on mortality are well established, which factor is more "important" remains controversial and is often debated by researchers. The fitness-fatness hypothesis suggests that a higher level of cardiorespiratory fitness substantially reduces the adverse effects of overweight and obesity on morbidity and mortality, making obesity a much less important factor for health than is generally believed. Numerous studies have examined the joint association of fitness and fatness on mortality,[25-29, 53-61] and the evidence strongly supports the hypothesis that fitness is much more important than fatness as a health indicator.

In an effort to better evaluate the roles of fitness and fatness in relation to health, we conducted an extensive literature review and meta-analysis on studies examining the joint associations of fitness and fatness on all-cause and mortality.

METHODS

A Medline search was performed using appropriate terms to assess the joint association between cardiorespiratory fitness (CRF) and body mass index (BMI) on mortality from all-causes ("Cardiorespiratory fitness" OR "physical fitness" OR fitness OR "maximal oxygen consumption" OR VO2max OR "maximal oxygen uptake" AND "Body composition" OR BMI OR "body mass index" OR obesity OR adiposity AND Mortality OR mortalities OR death OR fatality OR fatal OR "all-cause mortality"). In doing so, 384 titles were retrieved for an initial assessment. Relevant articles were set aside for abstract and full article assessments.

TABLE 2. Inclusion and Exclusion Criteria

Article Inclusion Criteria	
Exposure assessment	Articles jointly assessed BMI and CRF on one or both of the desired outcomes (cardiovascular and all-cause mortality).
CRF assessment	Objectively measured via an exercise test (i.e. treadmill or cycle ergometry).
Obesity assessment	Directly measured BMI.
Outcome assessment	All-cause mortality.
Design	Prospective design.
Article Exclusion Criteria	
Reference group	The Reference group was not the normal weight fit group

This process was performed twice. After completing this assessment review articles[62, 63] were checked for additional reports on fitness and fatness in relation to health. In total 14 articles met the inclusion criteria. (Table 2)

The exclusion criterion was then applied to the remaining articles. Two articles were excluded for not reporting point estimates.[30, 54] Two articles were excluded because the normal weight fit group was not the referent group[29, 64] and 1 article provided the joint association using percent body fat and waist circumference instead of BMI.[58] This left 8 articles that were included in the final analysis.[26–28, 57, 59, 60, 65, 66] From the 8 included articles we were able to assess the joint association between body composition (i.e. normal weight and overweight) and CRF level (i.e. fit and unfit) to all-cause mortality. In doing so there were 3 groups assessed (i.e. normal weight unfit, fat unfit and fat fit) and compared to the referent group (i.e. normal weight fit). In the analysis overweight and obese individuals were considered to have similar mortality risk because the original articles find no difference in hazard ratio between these groups. Therefore, participants in these categories were grouped in the analyses and are identified as 'overweight', so this category also includes those who are obese. Participants who had moderate and high fitness levels were also considered to have similar mortality risks as shown by the hazard ratios in the original articles and, therefore, were also presented together, and labeled as "fit." Seven of the 8 articles provided data for all 3 comparison groups[26–28, 57, 59, 60, 66] while 1 article fit the inclusion/exclusion criteria (i.e. reference group) in only the normal weight unfit comparison.[65]

Seven of the 8 articles used CRF quintiles to define the unfit (1st quintile) and fit (2nd–5th quintile) categories. The eighth article assigned predefined MET ranges to low (i.e. <5 METs), moderate (5–10 METs), and high fitness (>10 METs) levels.[66] Detailed information about the 8 articles can be found in Table 3.

The referent group for this analysis are participants who were normal weight and fit. There were two ways the original articles reported the fitness categories: fit vs. unfit; or low, moderate and high fitness. The former articles, fit vs. unfit, had a referent group of moderate and high fit individuals. The later articles, with low, moderate and high fitness levels, had a high fit referent group. In this analysis the two referent groups are considered similar and are referred to as the normal weight 'fit' group.

The pooled hazard ratios for the joint BMI and CRF association with mortality were estimated using a random-effects model. Two-sided $P \leq 0.05$ was considered statistically significant. Data were analyzed using Comprehensive Meta Analysis version 2.2.050 (Comprehensive Meta Analysis, Englewood, New Jersey).

RESULTS

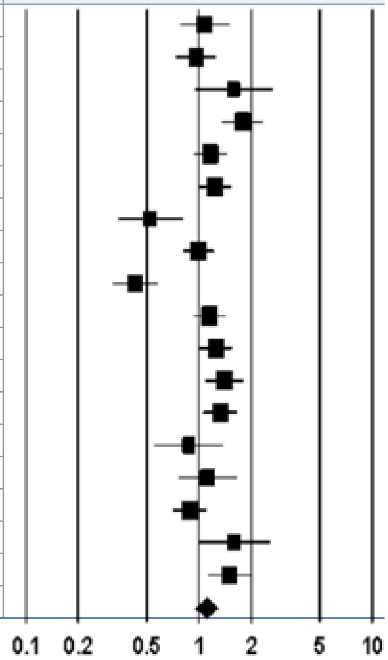
The three following figures present summary data from the meta-analysis. The figures show the hazard ratios and 95% confidence intervals for each study, and each subgroup in a study that had more than one population subgroup. The reference category for analyses for all three figures was the normal weight and fit group.

TABLE 3. Characteristics of 8 Studies Examining the Joint Association of BMI, Fitness, and All-cause Mortality

Study (reference)	Year	Study population	Follow-Up (mean years)	Outcome (No. of deaths)	Main findings	Covariates
Lee et al.[57]	1998	**Aerobics Center Longitudinal Study** (21,856 men; age 30-83)	8.1	427	**RR for fit and unfit:** BMI 19-25: 1.00, 2.25 BMI 25-27.8: 0.96, 1.68 BMI ≥27.8: 1.08, 2.24	Age, exam year, smoking, and alcohol
Wei et al.[27]	1999	**Aerobics Center Longitudinal Study** (25,714 men; mean age 43.8)	~10	1025	**RR for not low and low fitness:** BMI 19-25: 1.0, 2.2 BMI 25-29.9: 1.1, 2.5 BMI ≥30: 1.1, 3.1	Age, exam year
Wei et al.[67]	2000	**Aerobics Center Longitudinal Study** (1,263 men; mean age 50)	12	180	**RR:** Low fit/normal weight (BMI<25): 2.9 Fit/normal weight (BMI<25): 1.0 Low fit/overweight (BMI≥25): 2.8 Fit/overweight (BMI≥25): 1.0	Age, exam year
Stevens et al.[60]	2002	**Lipid Research Clinics Study** (2,506 women and 2,860 men; age 30-75)	?	**Women:** 484 **Men:** 682	**Women:** Fit, not fat 1.00 Fit, fat 1.32 Unfit, not fat 1.30 Fit Fat 1.57 **Men:** Fit, not fat 1.00 Fit, fat 1.23 Unfit, not fat 1.44 Fit Fat 1.49	Age, education, smoking, alcohol intake, dietary Keys score
Stevens et al.[59]	2004	**Lipid Research Clinics Study** (1,359 Russian men and 1,716 US men; age 40-59 years)	17.6	**Russian Men:** 211 **US Men:** 460	**Russian Men:** Fit, not fat 1.00 Fit, fat 0.87 Unfit, not fat 1.86 Fit Fat 1.68 **US Men:** Fit, not fat 1.00 Fit, fat 1.40 Unfit, not fat 1.41 Fit Fat 1.54	Age, education, smoking, alcohol intake, dietary Keys score
Sui et al.[28]	2007	**Aerobics Center Longitudinal Study** (2603 adults; age 60-100)	12	450	**HR for fit and unfit:** <18.5 BMI: 1.00, 3.63 18.5-24.9 BMI: 0.88, 1.74 25-29.9 BMI: 1.12, 1.68 ≥30 BMI: 0.86, 3.35	Age, sex, examination year, smoking status, abnormal exercise ECG response, CVD, HTN, diabetes, hypercholesteremia
McAuley et al.[26]	2009	**Aerobics Center Longitudinal Study** (13,155 hypertensive men; mean age 47.7)	12	883	**HR across low, moderate, high fitness:** BMI18.5-24.9: 2.77, 1.66, 1.00 BMI 25-29.9: 2.21, 1.24, 1.16 BMI ≥30: 2.95, 1.78, 1.59	Age, exam year, inactive, smoking, alcohol, BP, chronic conditions, family history of CVD
McAuley et al.[66]	2010	**The Veterans Exercise Testing Study** (12,417 men; age 40-70)	7.7	2801	**HR for low, mod, high fitness:** <18.5 BMI: 4.48, 3.09, N/A 18.5-24.9 BMI: 2.03, 1.65, 1.00 25-29.9 BMI: 1.79, 1.15, 0.43 ≥30 BMI: 1.61, 0.99, 0.52	Age, ethnicity, exam year, CVD, HTN, dyslipidemia, diabetes, smoking, CVD medications

FIGURE 13. Meta-analysis of All-Cause Mortality on Fat Fit Individuals*

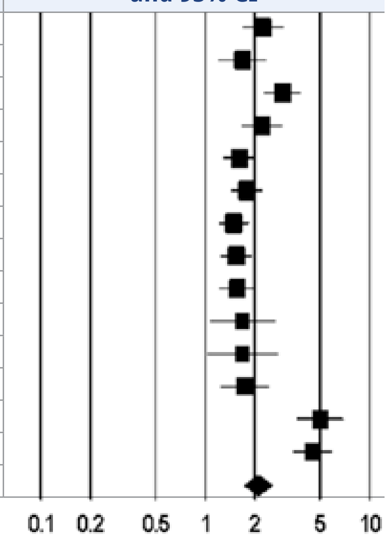
Study author/ year*†	Weight status	Fitness status‡	Hazard ratio	Lower limit	Upper limit	Hazard ration and 95% CI
Lee et al. 1998	Obese	Mod/high	1.08	0.77	1.51	
Lee et al. 1998	Overweight	Mod/high	0.96	0.73	1.26	
McAuley et al. 2009	Obese	High	1.59	0.95	2.67	
McAuley et al. 2009	Obese	Mod	1.78	1.35	2.34	
McAuley et al. 2009	Overweight	High	1.16	0.93	1.45	
McAuley et al. 2009	Overweight	Mod	1.24	0.99	1.55	
McAuley et al. 2010	Obese	High	0.52	0.34	0.81	
McAuley et al. 2010	Obese	Mod	0.99	0.80	1.23	
McAuley et al. 2010	Overweight	High	0.43	0.32	0.58	
McAuley et al. 2010	Overweight	Mod	1.15	0.93	1.42	
Stevens et al. 2002	Overweight/Obese	Mod/high	1.25	1.00	1.56	
Stevens et al. 2004	Overweight/Obese	Mod/high	1.40	1.07	1.83	
Stevens et al. 2002w	Overweight/Obese	Mod/high	1.32	1.05	1.66	
Stevens et al. 2004r	Overweight/Obese	Mod/high	0.87	0.55	1.37	
Sui et al. 2007mw	Obese	Mod/high	1.12	0.76	1.66	
Sui et al. 2007mw	Overweight	Mod/high	0.88	0.70	1.11	
Wei et al. 1999	Obese	Mod/high	1.60	0.99	2.58	
Wei et al. 1999	Overweight	Mod/high	1.50	1.11	2.02	
Overall			1.10	0.95	1.27	



* Compared to normal weight high fit individuals; † the analyses were in men unless otherwise reported; ‡ Mod and high are moderate and high cardiorespiratory fitness; w, analysis in women; r, analysis in Russian men; mw, analysis in men and women.

FIGURE 14. Meta-analysis of All-Cause Mortality on Fat Unfit Individuals*

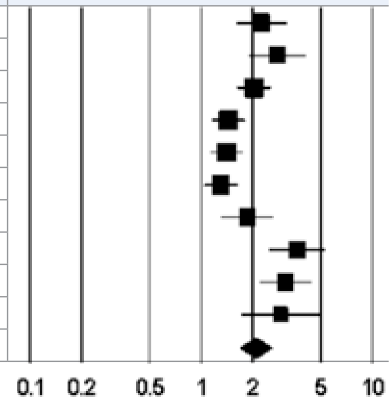
Study author/ year*†	Weight status	Fitness status‡	Hazard ratio	Lower limit	Upper limit	Hazard ration and 95% CI
Lee et al. 1998	Obese	2.24	1.68	2.98	1.51	
Lee et al. 1998	Overweight	1.68	1.19	2.37	1.26	
McAuley et al. 2009	Obese	2.95	2.28	3.82	2.67	
McAuley et al. 2009	Overweight	2.21	1.65	2.96	2.34	
McAuley et al. 2010	Obese	1.61	1.27	2.04	1.45	
McAuley et al. 2010	Overweight	1.79	1.43	2.25	1.55	
Stevens et al. 2002	Overweight/Obese	1.49	1.20	1.85	0.81	
Stevens et al. 2004	Overweight/Obese	1.54	1.23	1.93	1.23	
Stevens et al. 2002w	Overweight/Obese	1.57	1.21	2.05	0.58	
Stevens et al. 2004r	Overweight/Obese	1.68	1.06	2.67	1.42	
Sui et al. 2007mw	Obese	1.68	1.02	2.77	1.56	
Sui et al. 2007mw	Overweight	1.74	1.23	2.46	1.83	
Wei et al. 1999	Obese	5.00	3.59	6.98	1.66	
Wei et al. 1999	Overweight	4.5	3.39	5.98	1.37	
Overall		2.08	1.70	2.55	1.66	



* Compared to normal weight high fit individuals; † the analyses were in men unless otherwise reported; w, analysis in women; r, analysis in Russian men; mw, analysis in men and women.

FIGURE 15. Meta-analysis of All-Cause Mortality on Normal Weight Unfit Individuals*

Study author/ year*†	Weight status	Fitness status‡	Hazard ratio	Lower limit	Upper limit	Hazard ration and 95% CI
Lee et al. 1998	Normal Weight Unfit	2.25	1.59	3.18	1.51	
McAuley et al. 2009	Normal Weight Unfit	2.77	1.87	4.10	1.26	
McAuley et al. 2010	Normal Weight Unfit	2.03	1.60	2.58	2.67	
Stevens et al. 2002	Normal Weight Unfit	1.44	1.14	1.81	2.34	
Stevens et al. 2004	Normal Weight Unfit	1.41	1.12	1.77	1.45	
Stevens et al. 2002w	Normal Weight Unfit	1.30	1.03	1.64	1.55	
Stevens et al. 2004r	Normal Weight Unfit	1.86	1.32	2.63	0.81	
Sui et al. 2007mw	Normal Weight Unfit	3.63	2.47	5.33	1.23	
Wei et al. 1999	Normal Weight Unfit	3.10	2.17	4.43	0.58	
Wei et al. 2000	Normal Weight Unfit	2.90	1.71	4.92	1.42	
Overall		2.07	1.66	2.59	1.56	



* Compared to normal weight high fit individuals; † the analyses were in men unless otherwise reported; w, analysis in women; r, analysis in Russian men; mw, analysis in men and women.

Figure 13 shows results for all-cause mortality in fat individuals who were fit. The majority of the hazard ratios were not significantly different from 1.0 (referent category of normal weight and fit individuals). The overall hazard ratio was 1.098 and the 95% confidence interval was 0.948 to 1.272. Compared with normal weight and fit individuals, fat individuals who were fit had no significantly greater risk of dying in comparison to normal weight and fit individuals.

FIGURE 16. Relationship between Cardio-respiratory Fitness, BMI, and All-cause Mortality across Studies

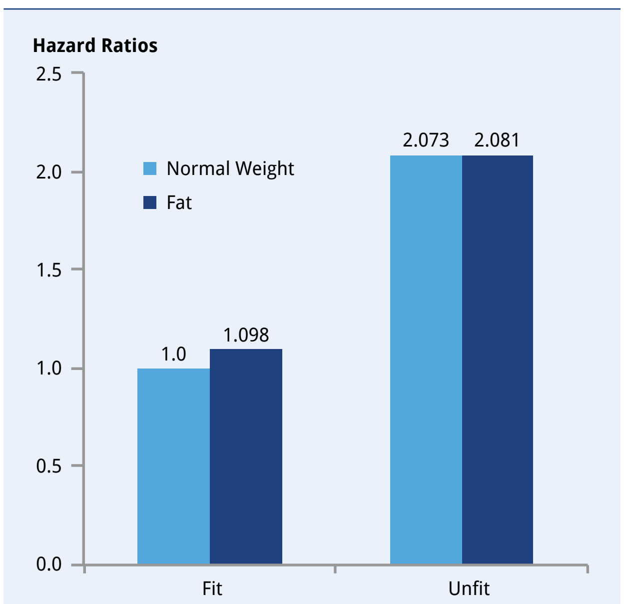


Figure 14 shows results for all-cause mortality in fat and unfit individuals. All of the hazard ratios were significantly above 1.0 (referent category of normal weight and fit individuals). Note that the overall hazard ratio was 2.081 and the 95% confidence interval does not include 1.0 (1.698-2.551). Fat and unfit individuals were more than twice as likely to die during the follow-up period when compared with their fit, normal weight counterparts.

Figure 15 presents the results for normal weight individuals who also were unfit. Hazard ratios for all studies were significantly above 1.0 (referent category of normal weight and fit individuals). The overall hazard ratio was 2.073, with a confidence interval of 1.662 to 2.585. Unfit, normal weight individuals were more than twice as likely to die during the follow-up period when compared with fit, normal weight individuals.

Figure 16 summarizes the relationship between cardiorespiratory fitness, BMI, and all-cause mortality across the 8 studies as determined by the meta-analysis. The risk of death for individuals who were fat and fit was not significantly greater than the risk for individuals who were normal weight and fit. The risk of death for individuals who were fat and unfit, or normal weight and unfit was significantly greater than the risk for individuals who were normal weight and fit. The mortality risk in unfit, normal weight individuals was very similar to the risk in unfit, fat individuals. It is clear that fitness is a strong determinant of mortality, irrespective of body weight, and that fatness is of little importance when fitness is taken into account in the analyses.

DISCUSSION

Obesity is a public health problem, with billions of dollars being spent on weight-loss efforts annually. The American public has clearly demonstrated that decades of focusing on dieting to lose weight is not stopping the obesity epidemic. Many Americans struggle unsuccessfully to avoid gaining weight, to lose weight, or to maintain weight loss. In terms of reducing risk for mortality, findings from this meta-analysis suggest that public health efforts should not be aimed at reducing BMI, but instead they should focus on getting individuals to be more physically active, and thus fit. The belief that improvements in health can only be attained through weight loss is simply not true; people who are overweight or obese are not automatically at a higher risk for morbidity and mortality. We found that the risk of death was similar for unfit and fit individuals, regardless of BMI. That is, fit individuals who were normal weight had a death risk similar to fit individuals who were fat. Similarly, the risk of death for unfit individuals who were normal weight was comparable to the death risk of unfit individuals who were fat. These findings are promising for individuals who are unable to lose weight or maintain weight loss, as they can still experience health benefits by increasing and maintaining a moderate level of fitness by participating regularly in physical activity (e.g. brisk walking, biking).

The findings from this meta-analysis have important public health implications. Physical activity, and thus fitness, is more malleable than dieting to manage weight, as efforts to maintain weight loss have largely been failures. Researchers, clinicians, and public health officials should focus on physical activity-based interventions. Much more attention should be given to promoting physical activity as a means to reduce risk for disease and death, not as a means to lose weight. Individuals who exercise purely for weight loss reasons will not likely stick with it when immediate results are not achieved. The amount of activity needed to develop the moderate level of fitness found in our meta-analysis to be highly protective is consistent with the DHHS 2008 Physical Activity Guidelines, 150 minutes of moderate intensity activity/week, which can be accumulated in doses of 10 minutes or more. We believe it will be easier to get large numbers of people to take three 10 minute walks/five days of the week (thus, accumulating the target of 150 minutes/week) than to get large numbers of people to diet, lose, and then maintain weight loss. This amount of activity should not be intimidating to sedentary individuals, and is achievable by most. A number of evidence-based programs for promoting physical activity using a number of approaches, channels, and settings exist, and meaningful increases in physical activity have resulted.[68, 69] However continued work is needed, particularly in how to successfully translate and disseminate these programs so they can have broader reach and impact among diverse populations.

CONCLUSIONS

Regular physical activity, which leads to beneficial levels of cardiorespiratory fitness, can make huge contributions to overall positive health. Indeed, one might argue that "good fitness is positive health." It seems unlikely that positive health can be achieved without regular physical activity leading to good levels of various functional indicators of health.

We focus on two key topics in this White Paper. The first is that the obesity epidemic, identified by many as one of the biggest public health problems facing the world, is largely due to declining levels of occupational energy expenditure. This conclusion calls for a major refocusing of efforts to deal with the obesity epidemic. The constant attention to dieting for weight loss over the past decades has largely been a failed enterprise, and new approaches are needed. It is obvious that we are not going back to occupational energy expenditures of the middle of the 20th century, so we must apply new strategies and tactics to deal with this public health problem. Fortunately we now have a U.S. National Physical Activity Plan that was released May 3, 2010 (www.physicalactivityplan.org). The Plan presents a broad array of strategies and tactics for promoting physical activity and making the American public healthier. High levels of Positive Health across the population are unlikely to be achieved unless we are successful in promoting physical activity. Having a better understanding of the relative importance of occupational physical activity in the ongoing obesity epidemic should help in the formulation of a comprehensive evidenced-based plan to combat this continuing problem.

A second major conclusion of this White Paper is that fitness is far more important than fatness as a contributor to overall health. We submit that physical activity, leading to good fitness, is a more malleable behavior that dieting to lose weight.

Professor Jerry Morris, inventor of the field of physical activity epidemiology in the middle of the past century, described our current situation, "We in the West are the first generations in human history in which the mass of the population has to deliberately exercise to be healthy. How can society's collective adaptations match?"[70] This is an accurate characterization of the current situation in the U.S. and many other countries. We must become more creative in helping more individuals meet current physical activity guidelines, as a major public health challenge remains in getting more people, more active, more of the time. High levels of Positive Health are unlikely to be achieved unless we are successful with this endeavor.

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