Physical activity after total hip arthroplasty

Wagenmakers, Robert

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Stellingen

Behorend bij het proefschrift

Physical activity after Total Hip Arthroplasty

1. Regelmatige lichamelijke activiteit is een van de belangrijkste leefstijlfactoren die van invloed is op de gezondheid en de gezondheidsgerelateerde kwaliteit van leven van personen in de moderne westerse samenleving (this thesis).
2. Het fragmentarische inzicht in het lichamelijke activiteitenpatroon van patiënten na een totale heupartroplastiek staat in schril contrast met het maatschappelijke belang dat aan lichamelijke activiteit moet worden toegekend (this thesis).
3. Het vermogen om weer lichamelijk actief te zijn wordt door veel patiënten na een totale heupartroplastiek onvoldoende benut (this thesis).
4. De SQUASH (short questionnaire to assess health-enhancing physical activity) is de eerste vragenlijst die een gedetailleerd inzicht geeft in het lichamelijke activiteitenpatroon van patiënten met een totale heupprothese(this thesis).
5. Mannen met een primaire heupprothese voldoen significant vaker aan de richtlijnen voor gezondheidsbevorderende lichamelijke activiteit dan vrouwen (this thesis).
6. Those who think they have not time for bodily exercise will sooner or later have to find time for illness. Edward Stanley, British Statesman (1826-1893).
7. De Nederlandse Orthopaedische Vereniging (NOV) zou er goed aan doen haar motto "zorg voor beweging" meer letterlijk op te vatten.
8. De huidige beweging op de financiële markten zal ook daar uiteindelijk leiden tot een betere (financiële) gezondheid.
9. De orthopedische patiënt van nu wordt, na behandeling in een productiestraat, via het juiste zorgpad, zo snel mogelijk weer de laan uitgestuurd.
10. In het leven heeft men vaak de keuze om links- of rechtsom te gaan. Helaas geldt dit niet voor het inhalen op de snelweg.
11. Het geluidsniveau waarmee een mobiel telefoongesprek in de trein wordt gevoerd is omgekeerd evenredig met het niveau van de inhoud.
12. Met de invoering van het rookverbod in de horeca heeft de overheid eindelijk gezorgd voor meer blauw op straat.

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Voor Esther, Esmée en Casper.

Contents

CHAPTER 1

General Introduction

In modern Western society, regular physical activity is increasingly being recognized as one of the most important lifestyle behaviors affecting health. It has been shown to be effective in the primary and secondary prevention of a range of chronic conditions, such as cardiovascular disease, type-2 diabetes, colon and breast cancer, hypertension, obesity and osteoporosis, and is linked to a reduction in all-cause mortality.[1,2] It also plays an important role in the maintenance and enhancement of musculoskeletal fitness.[3,4] At the same time, a lack of physical activity is considered to be an important burden on public health,[5] contributing, together with an unhealthy diet, to the epidemic of obesity in Western society.[6,7]

In face of the beneficial effects of regular physical activity, guidelines have been established for recommended amounts of health-enhancing physical activity.[8,9] Every healthy adult aged 18 to 65 is recommended to perform 30 minutes or more of moderate-intensity aerobic (endurance) physical activity on at least 5 days per week, or to perform vigorous-intensity aerobic physical activity for a minimum of 20 minutes on at least 3 days per week. Adults are also advised to perform activities that maintain or increase muscle strength and endurance.[8] These recommendations for health-enhancing physical activity also apply generally to older adults (men and women age ≥ 65).[9] However, older adults not only face the occurrence of chronic conditions, but also a number of functional declines associated with aging that can threaten their independent performance of activities of daily living. This, in turn, can have a major impact on their quality of life. For this reason, the American College of Sports Medicine/American Heart Association (ACSM/AHA) 2007 position on exercise and physical activity for older adults recommends that older individuals participate in regular exercise programs aimed at improving overall health as well as cardiorespiratory and musculoskeletal fitness. To achieve these goals, regular regimens involving strengthening, stretching, and balance exercises are recommended for older adults in addition to cardiorespiratory endurance activities. In this way, a number of these age-associated functional declines may be countered and functional independence preserved.

Despite these recommendations, a major portion of the population is still insufficiently physically active. For example, in 2007 only 39.3% of American adults aged ≥ 65 reported meeting the physical activity recommendations in an average week.[10] In the Netherlands in 2007, 66% of adults aged ≥ 55 met these recommendations.[7]

The ability to be physically active can be severely hindered by the occurrence of chronic conditions such as osteoarthrosis (OA) of the hip. This joint disorder is one of the most prevalent age-related musculoskeletal conditions, leading to a significant impairment in the patient's ability to perform activities of daily living and a high impact on health-related quality of life.[11,12] In the US population symptomatic OA of the hip is reported to affect 8.7% of men and 9.3% of women aged 45 years and older.[13] Among the Dutch population, in 2000 these prevalence rates varied between 2.45% for males and 5.0% for females.[14] Since the introduction in the 1960s by Sir John Charnley of the concept of low-friction arthroplasty,[15] total hip arthroplasty (THA) has evolved into the preferred treatment for advanced OA of the hip. Nowadays it is one of the most frequently performed procedures in orthopedic surgery, with 202,500 THAs performed in the United States in 2003[16] and 22,500 in the Netherlands in 2005.[17] In the coming decades these numbers are expected to increase dramatically due to the projected growth of the older population and lowering thresholds for surgery.[17-20] Without considering eventual changes in age- and sex-specific arthroplasty rates, the annual number of THAs in the Netherlands is expected to increase to 25,090 in 2020,[19] and in the United States, with a 174% growth, to 572,000 in 2030.[17]

A large, growing and mostly older subset of the population will thus consist of patients after THA. These patients may be expected to also benefit from the effects of regular physical activity on health and musculoskeletal fitness. It will not only help to prevent disease, but also contribute to ensure their independent living by counteracting the functional declines associated with aging which threaten functional autonomy. In that way, regular physical activity will offer a major contribution to their quality of life.

So far, little is known about the physical activity behavior of patients after THA. Studies addressing physical activity of patients after THA are sparse and predominantly pertain to sports and walking activities.[21-34] Others have only used scores such as the UCLA activity score,[35-39] which categorizes patients according to their physical activity level. However, none of these studies has provided detailed information with respect to the habitual physical activity behavior of patients after THA. Furthermore, so far physical activity after THA has only been considered in the perspective of its role as an important negative determinant of prosthesis wear and loosening,[40] affecting the longevity of the implanted prosthesis. Even from this perspective more insight is needed into the physical activity behavior of patients after THA, to allow for a fairer and more precise comparison between the results of procedures performed with different prosthetic designs and/or bearing couples[41,42] and to put more perspective on the observed lower survival rates of total hip prostheses in younger patients,[43] which is predominantly attributed to a presumed higher activity level in these younger patients.

For these reasons, a more detailed insight into the habitual physical activity behavior of patients after THA is needed.

Scope and outline of this thesis

This thesis aims to provide a first insight into the habitual physical activity behavior of patients after THA. The main focus will lie on the assessment of this behavior from the perspective of its beneficial effects on general health and musculoskeletal fitness.

Chapter 2 provides the theoretical background on the interrelationships between physical activity, fitness and health in the context of the Bouchard (Toronto) model. It describes the beneficial effects of regular physical activity on general health and musculoskeletal fitness, as well as the negative effects of sedentary behavior. The recently updated recommendations of the American College of Sports Medicine and American Heart Association on the types and amounts of health-enhancing physical activity in adults and older adults are outlined. This chapter also presents the current knowledge base for physical activity performed by patients after THA, and discusses the pros and cons of physical activity for such patients. Finally, it discusses the assessment of physical activity behavior within an orthopedic context.

As there is so far no specific questionnaire to assess the habitual physical activity behavior of patients after THA, ***Chapter 3*** analyzes if one of the most frequently used disease-specific outcome measures after THA, the Western Ontario and McMaster universities osteoarthritis index (WOMAC), is predictive for the amount of physical activity of patients after THA.

In ***Chapter 4*** the measurement properties of the Short QUestionnaire to ASsess physical activity (SQUASH) in patients after primary THA are determined. The SQUASH is used in the Netherlands to assess physical activity behavior as well as compliance with national and international recommendations for health-enhancing physical activity of the general population, but its reliability and validity have only been assessed in a healthy, adult population. As it is important to assess a questionnaire's measurement properties in every population in which it will be used, we assessed its reliability and validity in a population of patients after THA.

Chapter 5 describes the results of a retrospective study into the physical activity behavior of patients after primary THA. It gives an impression of this behavior in a population of patients who had a THA at University Medical Center Groningen at least one year before enrolment in this study. Physical activity behavior of patients after THA will be compared to that performed by a matched norm population.

Chapter 6 explores to what extent aspects of patient characteristics (age, gender, family status, education and comorbidity) are predictive for the level of physical activity of patients with a THA.

Chapter 7 describes the results of a prospective study into the physical activity behavior of patients one year after primary THA. It delineates the physical activity of these patients, compliance with recommendations for health-enhancing physical activity, and determinants of physical activity one year after the operation.

Chapter 8 provides a general discussion of the studies presented in this thesis and outlines practical implications as well as recommendations for future research. The thesis ends with a summary of its contents.

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CHAPTER 2

PHYSICAL ACTIVITY AFTER TOTAL HIP ARTHROPLASTY

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ABSTRACT

Background: Maintaining the health-related quality of life of the growing number of older adults is a challenging goal set to society in the coming decades. An important subset of this population is formed by patients after Total Hip Arthroplasty (THA). So far little attention is being paid to the health-enhancing effects of regular physical activity in this subset of the population, and little is known about the physical activity behavior of these patients.

Methods: An overview of the pros and cons of physical activity in general, and in patients after THA in particular, and an analyses of the available information about physical activity in patients after THA.

Results: Based on current knowledge patients should be advised to comply with the recommendations of health-enhancing physical activity. However, when choosing activities patients should account for the presence of a hip prosthesis and preferably participate in low-impact, low-contact activities, avoiding high-contact, high-impact activities with sudden repeated impacts and forced rotation with weight-bearing.

Conclusions: So far little is known about the physical activity behavior of patients after THA. Insight in this behavior is needed not only from a health-perspective, but also from an orthopedic perspective as it can give more insight in the performance of hip prostheses. Therefore more attention to the recommendation and evaluation of this behavior has to be paid

INTRODUCTION

In the coming decades, Western society will face a sharp increase, in both relative as well as absolute terms, in the number of older adults.[1] As aging is associated with declining fitness and the occurrence of age-related chronic conditions, one of the major challenges facing society in the coming decades will be to ensure the health and health-related quality of life of this population. This is not only important from an individual point of view, as good health is an important prerequisite for independent functioning and the ability to participate in society, but also from a societal perspective; the growing number of older adults will put an increasing demand on the health care system, contributing to the expected increase in future health care expenditures.[2,3]

Preventing or reducing some of these negative aging effects on health could, therefore, have significant individual as well as societal benefits. Although some of these negative aging effects are due to the aging process itself and ultimately irreversible (primary aging), there are others which are influenced by lifestyle behaviors, personal attributes, and physical and social environmental factors (secondary aging) and, therefore, potentially reversible or preventable.[4] One of the most important lifestyle behaviors which has been shown to preserve and promote health and function is regular physical activity. Regular physical activity has proven to be effective in the prevention of a range of chronic diseases and conditions as well as the enhancement of musculoskeletal fitness, and is linked to a reduction in all-cause mortality.[5-8] At the same time a lack of physical activity is considered to be an important burden on public health in Western societies.[9]

The ability to be physically active can be severely hindered by the occurrence of chronic conditions such as osteoarthrosis (OA) of the hip. This joint disorder is one of the most prevalent age-related musculoskeletal conditions, leading to a significant impairment in patients' ability to perform activities of daily living and having a large impact on health-related quality of life.[10,11] In the US population symptomatic OA of the hip is reported to affect 8.7% of men and 9.3% of women aged 45 years and older.[12] Among the Dutch population, these prevalence rates varied in 2000 between 2.45% for men and 5.0% for women.[13] Although Total Hip Arthroplasty (THA) is a highly successful and widely applied treatment for advanced osteoarthrosis of the hip, with 202,500 primary THAs performed in the United States in 2003[14] and 22,500 in 2005 in the Netherlands,[15] little is known about the physical activity behavior of patients after THA. The scarce knowledge we have is mainly limited to its role as an important negative determinant of prosthesis wear and loosening, affecting the longevity of total hip prostheses.[16-18]

With the recognition of regular physical activity as an important lifestyle behavior affecting health, more attention to the potential role of regular physical activity for the health and functioning of THA patients is warranted. Furthermore, it may be expected that orthopedic surgeons, physical therapists, and other professionals involved in the care of patients after THA will be increasingly encouraged to counsel post-THA patients on physical activity given its beneficial health effects. Therefore, the objectives of this paper are to 1) increase the awareness and knowledge of the beneficial health effects of regular physical activity among professionals involved in the care of patients after THA; 2) present the current knowledge base with respect to physical activity performed by patients after THA and discuss the pros and cons of physical activity for patients after THA; and 3) discuss the assessment of physical activity behavior within an orthopedic context.

The Bouchard (Toronto) model

The Bouchard (Toronto) model describes the interrelationships between physical activity, health-related fitness, and health. The model was developed by Bouchard et al.[19] and improved by Bouchard and Shephard (1994).[20] In the Bouchard (or Toronto) model (Figure 1), the reciprocal relationships between physical activity, health-related fitness, and health are represented.

Physical activity comprises any bodily movement produced by the contraction of skeletal muscle that substantially increases energy expenditure above the basal level.[21] It can be categorized in various ways, including type, intensity, and purpose of the physical activity. Common types of physical activity include transportation, occupational, household,

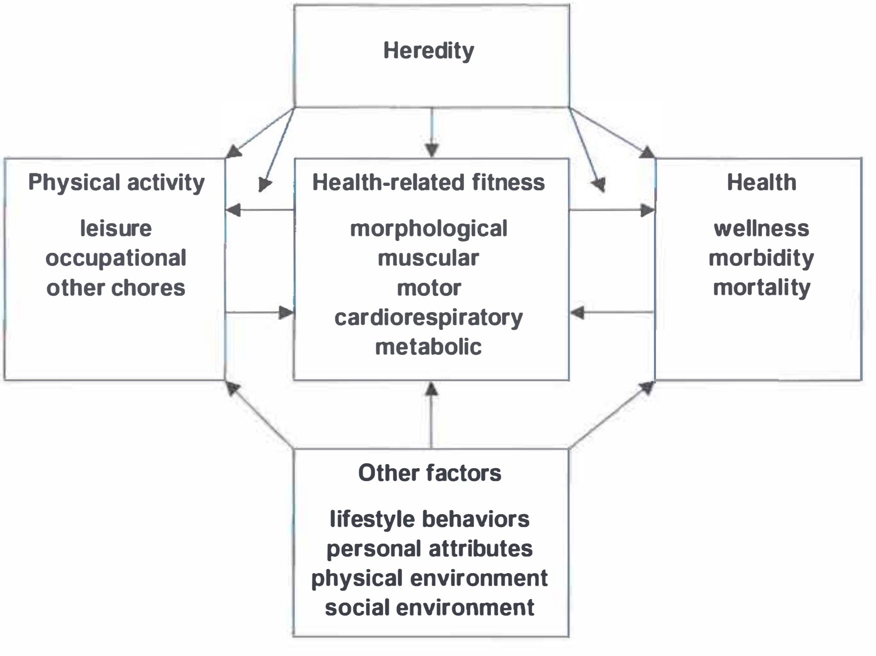

Figure 1: Bouchard (Toronto) model. The interrelationships between physical activity, health-related fitness and health[19,20]

sport or leisure-time physical activity. The intensity of physical activity can be expressed in relative terms, in relation to a person's capacity for a specific type of activity, using parameters such as heart rate, oxygen uptake, or rate of perceived exertion, or in absolute terms. With this latter method, commonly used in current public health recommendations and research reports aimed at the general population,[22] a specific activity is assigned a certain intensity, based on energy expenditure, and is expressed in for example Metabolic Equivalents (METs). One MET is an estimate of one's resting metabolic rate, and intensity can be expressed as the ratio of work metabolic rate to the resting metabolic rate. Based on laboratory and field measurements, the number of METs associated with a wide range of specific activities have been estimated and described in a compendium of physical activities.[23,24] In this way light, moderate, and vigorous intensity activities are recognized for the general adult population. However, an increasing recognition of the importance of relative capacity and fitness levels in prescribing appropriate levels of physical activity for older adults has occurred with the recently released U.S. national recommendations.[25] With respect to the general purpose of physical activity, a distinction can be made between exercise and physical activity. Although these terms are often used synonymously and closely relate to each other, exercise has been defined as a subcategory of physical activity that is planned, structured, and repetitive, with the purpose to improve or maintain one or more components of physical fitness.[21]

Physical fitness can be defined as the ability to carry out daily tasks with vigour and alertness, without undue fatigue, and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies.[5] It includes cardiorespiratory endurance, skeletal muscular endurance, skeletal muscular strength, skeletal muscular power, speed, flexibility, agility, balance, reaction time, and body composition. An important distinction has to be made between performance-related and health-related fitness.[21,26] Fitness components that are necessary for optimal work or sports activity are referred to as performance-related fitness. Health-related fitness concerns those fitness components that are affected favourably or unfavourably by physical activity and relate to health status. It includes cardiorespiratory and musculoskeletal fitness, body composition, and metabolism.[8]

Health is defined as a human condition with physical, social, and psychological dimensions, each characterized on a continuum with positive and negative poles. Positive health is associated with a capacity to enjoy life and to withstand challenges, and not merely the absence of disease. Negative health is associated with morbidity and, in the extreme, with premature mortality.[20]

The beneficial effects of physical activity

Physical inactivity is, together with unhealthy diet and smoking, one of the most important controllable lifestyle behaviors interfering with health and healthy aging. Regular physical activity has proven to be effective in the primary and secondary prevention of a range of chronic diseases and conditions, including cardiovascular disease, type-2 diabetes, colon and breast cancer, hypertension, obesity, depression, and osteoporosis, and is linked to a reduction in all-cause mortality.[5,8] Additionally, regular physical activity can enhance musculoskeletal fitness, which is positively associated with functional autonomy, mobility, and bone health, and negatively associated with the risks of falls.[6,7] These effects on musculoskeletal fitness are particularly important issues for aging persons who are vulnerable to the loss of functional autonomy (fig. 2). In order to live independently, a certain level of musculoskeletal fitness (above the threshold for dependence) is needed. As aging is associated with diminishing musculoskeletal fitness many older adults live at or near this threshold of dependence, and minor intercurrent illness may result in functional dependency. Regular physical activity can delay this age-related decline in musculoskeletal fitness and postpone reaching the threshold of dependence.[8,27] The quality of life of older adults largely depends on their ability to live independently.[28]

The negative effects of physical inactivity

Physical inactivity, on the other hand, is associated with premature death overall and as a result of specific chronic diseases such as coronary heart disease, colon cancer, and non-insulin dependent diabetes.[8] The strength of the association between a certain lifestyle behavior, in this case physical inactivity (sedentary lifestyle), and chronic diseases is usually

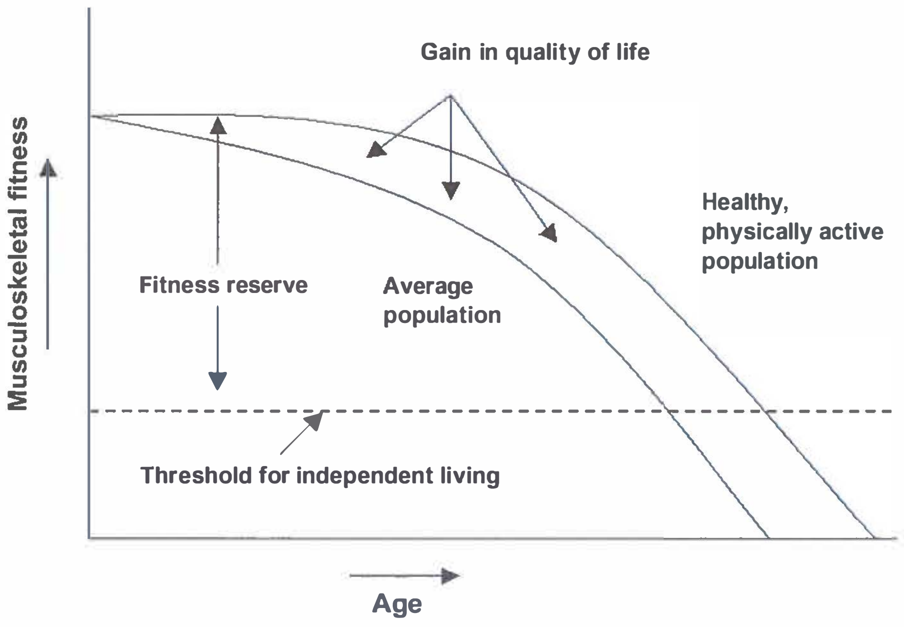

Figure 2. Relationship between musculoskeletal fitness and functional independency[82]

expressed as a relative risk (RR). For example, the RR of cardiovascular disease as a result of physical inactivity, based on methodologically satisfactory studies, varies between 1.5 and 2.4, which implies that chances of cardiovascular disease are 1.5 to 2.4 greater compared to a regularly physically active individual. This means that physical inactivity can be considered to be as great a potential risk for cardiovascular disease as other risk factors such as hypercholesterolemia, hypertension, and smoking. The RR for these lifestyle behaviors varies between 1.9 and 2.5.[29] Physical inactivity is not only important as an independent risk factor, but also because it contributes to the detrimental aspects of other risk factors.[30] Together with poor diet, physical inactivity is one of the major contributors to the epidemic of obesity affecting society.

For these reasons physical inactivity is considered to be a major public health issue, reflected in the issuing of recommendations of health-enhancing physical activity,[22,25,31,32] as well as the prominent place given to enhancement of physical activity in several national and international health promotion programs.[33]

Health-enhancing physical activity recommendations

Current recommendations of health-enhancing physical activity are based on the recently published position stands of the American College of Sports Medicine (ACSM) and American Heart Association (AHA), published in 2007.[22,25]

Every healthy adult aged 18 to 65 yr is recommended to perform 30 minutes or more of moderate-intensity aerobic (endurance) physical activity on at least 5 days per week, or to perform vigorous-intensity aerobic physical activity for a minimum of 20 minutes on at least 3 days per week. Also, combinations of moderate- and vigorous-intensity activity can be performed to meet the recommendation. The activity can be performed either in a single session per day or accumulated in multiple bouts, each lasting at least 10 minutes. This recommended amount of aerobic activity is in addition to routine activities of daily living of light intensity or lasting less than 10 minutes in duration. Moderate-intensity physical activity is defined as activity performed at an intensity of 3 to 6 METs and is exemplified by a brisk walk, noticeably accelerating the heart rate. Vigorous-intensity physical activity, on the other hand, is defined as activity performed at an intensity >6 METs, exemplified by jogging, and causing rapid breathing and a substantial increase in heart rate. Additionally adults are advised to perform activities that maintain or increase muscle strength and endurance. For that reason they should perform 8-10 exercises using the major muscle groups on 2 or more non-consecutive days per week. To maximize strength development, a resistance (weight) should be used that allows 8-12 repetitions of each exercise resulting in volitional fatique.[22] The recommendations emphasize that health-related physical activity can be performed during daily life by adopting a more active lifestyle, not necessarily needing a regimented vigorous exercise program.

These recommendations of health-enhancing physical activity also apply generally to older adults (men and women age ≥65 yr).[25] However, older adults are not only faced with the occurrence of chronic conditions but also with a number of functional declines associated with aging that can threaten their independent performance of activities of daily living. This, in turn, can have a major impact on their quality of life. Therefore the ACSM/ AHA 2007 position stand on exercise and physical activity for older adults recommends that older individuals participate in regular exercise programs aimed at improving overall health as well as cardiorespiratory and musculoskeletal fitness. To achieve these goals, regular regimens involving strengthening, stretching, and balance exercises are recommended for older adults in addition to cardiorespiratory endurance activities.[25] In this way, a number of these age-associated functional declines may be prevented and functional independence preserved. In prescribing relevant moderate- and/or more vigorous-intensity activities for older populations the current recommendations for older adults emphasize the utility of using relative as opposed to absolute definitions of fitness. So, moderate- or vigorous-intensity aerobic activity involves a moderate or vigorous level of effort relative to an individual's aerobic fitness. On a 10-point scale, where sitting is 0 and all-out effort is 10, moderate-intensity activity is a 5 or 6 and produces noticeable increases in heart rate and breathing, while vigorous-intensity activity is a 7 or 8 and produces large increases in heart rate and breathing. In defining the level of effort for muscle-strengthening a same approach is used. Muscle-strengthening activity in older adults should consist of 10-15 repetitions per set.

The aforementioned physical activity recommendations for older adults also apply to adults age 50 to 64 yr with clinically significant chronic conditions and/or functional limitations.

In order to reduce the risks of musculoskeletal injuries or cardiovascular events (myocardial infarction, sudden cardiac arrest), previously sedentary people should gradually build up to the desired level of activity.[5] Furthermore, individuals who have either chronic disease, risk factors for chronic disease, or any other medical concern, are advised to consult a physician or health care provider prior to any substantive increase in physical activity, particularly vigorous-intensity activity, in order to design a safe and effective physical activity program. Asymptomatic adults who plan to be physically active at the minimum levels of moderate-intensity activity do not need such a consultation.[22] Every older adult on the other hand is advised to develop an activity plan in consultation with a physician or health care provider, not only to take advantage of expertise and resources on physical activity and injury prevention, but also to tailor the activity plan to older adults with chronic conditions, thereby integrating preventive and therapeutic recommendations.[25]

Compliance with health-enhancing physical activity recommendations

Despite the recognized, previously described benefits of physical activity and the potential detrimental effects of sedentary behavior, a major portion of the population remains insufficiently physically active. For example, in 2007, only 39 % of US adults aged ≥ 65 years reported meeting the physical activity recommendations in an average week.[34] In the Netherlands in 2007, 66% of adults aged ≥ 55years met these recommendations.[35]

The pros and cons of physical activity in older adults after THA

The pros of physical activity

Besides the important beneficial effects of regular physical activity on general health, some of the musculoskeletal effects of physical activity are of particular interest for older adults after THA. For example, improvement of muscle strength, balance, and coordination by means of regular physical activity has proven to be an effective strategy in the prevention of falls.[36,37] Each year about 30% of community dwelling older adults fall.[38] Of these people, approximately 5% sustain fractures and an additional 5% to 11% sustain other serious injuries.[39] In the presence of a total hip prosthesis, these falls may result in periprosthetic fracture, implant loosening, and/or dislocation of the hip prosthesis and cause serious morbidity. Such problems may even necessitate revision surgery, leading to additional or more prolonged periods of functional dependency.

Furthermore, there are indications that increased bone density due to physical activity improves prosthesis fixation, reducing the risk of prosthesis loosening.[40-42] Finally, physical activity might minimize bone loss due to stress shielding,[43] facilitating future revision surgery if needed, as preservation of the quality and quantity of cortical bone is important if revision should become necessary.

The cons of physical activity

One of the major concerns with respect to physical activity in patients after THA is its potential detrimental influence on longevity of the hip prosthesis. The most important factor limiting the longevity of hip prostheses is wear of the bearing surfaces. Although the process of wear is multi-factorial, including prosthesis-related as well as patient-related factors,[17] patient activity is considered to be the most important patient-related factor influencing wear.[16-18] This has lead to the statement that wear is a function of use, not time in situ.[16] The observed lower prosthesis survival rates in younger patients are generally considered to be a reflection of a higher physical activity level in this group as compared to older patients.[44] It is noteworthy that wear and subsequent loosening of the prosthesis in patients with higher activity levels may become apparent only after 10 years.[42,45]

With respect to longevity of the implanted hip prosthesis, weight of the patient deserves separate mention as another patient-related factor which may affect wear.

Overweight (i.e., body mass index (BMI) of 25-29.9 kg/m2) and obesity (BMI ≥ 30 kg/m2) constitute a growing epidemic in modern society. In the year 2006, an estimated 40% of adults over age 65 in the US were overweight, and another 22% were obese.[46] In the Dutch population, almost 57% of adults over age 65 in 2006 were overweight, while 14% were obese.[47] Overweight/obesity not only threatens general health, given their association with a substantially increased risk for diabetes mellitus, cardiovascular disease, some forms of cancer, and other chronic diseases,[48] but also might affect the longevity of total hip prostheses. Studies in this area have found a correlation between obesity and the risk of aseptic loosening.[18,49] Physical inactivity and poor diet are the major contributors to this growing epidemic of overweight and obesity, while on the other hand, increasing energy expenditure levels via regular physical activity forms an important part of programs to reduce weight. This is also true for patients after THA. Although obese patients often claim that the osteoarthritis in their hips limits their physical activity, studies have shown that THA does not typically lead naturally to weight loss.[50,51] A higher BMI has even been shown to be associated with lower activity in patients after THA.[52] For these reasons, physical activity programs are needed for overweight and obese patients following THA in order to increase energy expenditure and lower their weight.

A final objective of physical activity programs in older adults after THA should be to reduce the risk of musculoskeletal injuries or other adverse events such as cardiovascular events. In order to reduce the risk of these adverse events, previously sedentary people are advised to gradually build up their activity and consult a physician or other health professional in order to design a safe and effective exercise program that takes into account the existence of disabilities or important co-morbidities.[5,22,25]

Exercise recommendations after Total Hip Arthroplasty – Current Status

For the aforementioned reasons, the many potential benefits of regular physical activity should be considered within the context of potential detrimental effects. So far there is no clear consensus with regard to amount and type of physical activity that should be generally prescribed for patients after THA, particularly given that different subgroups of THA patients may require and benefit from different types of physical activity regimens. Prospective, randomized studies delineating guidelines for safe and appropriate activities after THA and assessing its effects on prosthesis survivorship are lacking. However, it can be assumed that the recommendations of health-enhancing physical activity which have been issued for older adults also generally apply to older adults after THA. With respect to types of physical activities which can be allowed to patients after THA current recommendations are based on personal preferences and surveys among orthopedic surgeons and mostly concern more strenuous athletic activities after THA.[53-57] However, these recommendations can probably be extrapolated to other types of physical activity, as the same considerations surrounding athletic activities can be applied to activities of daily living. Factors which must be taken into account are joint loads occurring during the activity, intensity of the activity, material properties of the implanted hip prosthesis, as well as skills of the patient in the specific activity. During activities of daily living, loads of 3 to 4 times body weight occur, while during sports activities, loads of 5 to 10 times bodyweight may occur.[55] As studies in the past have recognized the influence of load and loading cycles on prosthesis wear, activities with low joint loads are generally recommended (e.g., swimming, cycling). If carried out on a low intensity, recreational base, activities with higher loads can probably also be allowed.

So far, none of the exercise recommendations specifically account for the material properties of the implanted hip prosthesis. As new bearing surfaces (ceramics, highly cross-linked polyethylene, metals) may show improved wear characteristics, patient activity may be less of a risk factor for implant failure. However, until now long-term clinical follow-up studies showing advantages with these alternative bearing surfaces are lacking. Furthermore, the skills of the patient in a certain activity have to be considered. It is unwise to start technically demanding activities after a THA, as the joint loads and the risks of injuries are generally higher in unskilled individuals.[55]

In general, it is recommended that patients after THA take part in low-impact, low-contact activities and avoid high-contact, high-impact activities with sudden repeated impacts and forced rotation with weight-bearing in order to decrease the risk of wear and early loosening of the prosthesis, or the occurrence of dislocation or periprosthetic fracture.[53-55,58]

Physical activity behavior of patients after THA – current knowledge

So far little is known about the actual physical activity behavior of patients after THA and the extent to which these patients comply with general recommendations related to health-enhancing physical activity. Literature with respect to amount of physical activity is sparse and predominantly pertains to sport and walking activity.[40-42,59-69] The main focus of these studies has been on the determination of realistic loading conditions for hip prostheses and the implications of certain activities on implant survival, as well as on the return to specific activities after THA.

The number of step cycles (number of steps/2) per year in patients after THA aged ≥ 60 years has been shown to average between 0.8 – 1.9 million, with wide variations between patients.[62,63,65,70] Walking activity in these patients declines with age.[65] Patients aged <60 years were found to walk 30% more than those aged ≥60 years.[62,63] In general, men in these studies walked more than women.[62,63] The most frequent daily activities reported in a group of 31 patients (age 62.5 ± 11.5 years) after THA were sitting (44.3% of time), followed by standing (24.5%), walking (10.2%), lying (5.8%) and stair climbing (0.4%).[66]

With respect to sports activities after THA, Huch et al.[68] (2005) found in a group of patients with a mean age of 60.3 (± 9.1) years that the proportion of patients performing sports activities increased from 36% preoperatively to 52% 5 years postoperatively. Similarly, the proportion of patients performing sports activities for more than 2 hours a week increased from 8 to 14%. Meanwhile, Chatterji et al.[67] (2004) found that although the total number of patients performing sports increased from 80% preoperatively to 83% postoperatively, the total amount of sport played decreased, whereas patients adopted lower impact activities to participate in. Visuri and Honkanen[59] (1978) demonstrated an increase in sport participation (walking, cycling, swimming and/or cross-country skiing) from 19% to 68% postoperatively in a group of patients with a mean age of 63.8 years. On the other hand, Dubs et al.[40] (1983) (110 patients, all male, average age 55 years) found a large drop in the percentage patients performing sport, from 78% to 56% postoperatively. Ritter and Meding[60] (1987) also found a decrease in sports participation from 77% preoperatively to 56% postoperatively.

The level of physical activity has only been determined by means of categorical scoring tools such as the University of California Los Angeles activity score (UCLA)[71] and the Grimby scale.[72] Bauman et al.[73] (2007) found in a study population with a mean age of 66.4 (± 9.4) years after a mean follow up of 40.7 months a UCLA score of 6, corresponding to a moderate activity level. Beaulé et al.[74] (2006) evaluated 152 patients (mean age 58.7 years, range 21-87 years) with a mean follow-up of 5.2 years (range 2-21 years) and found a mean UCLA score of 6.8. Using the Grimby scale, Chatterji et al.[67] (2004) found a light-to-moderate intensity activity level (mean score 3.46 ± 1.21) in a postoperative study population with a mean age of 67.8 (± 10.2) years.

However, none of these studies addressed the physical activity behavior of patients after THA within the context of current health-enhancing physical activity recommendations. In a recent study, we analyzed the habitual physical activity behavior of Dutch patients after primary total hip arthroplasty (THA), using the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH),[75] and determined the compliance to (inter)national guidelines of health-enhancing physical activity. Results were compared to an age- and gender-matched normative population.[76] We found that after a mean follow up of 39 months patients after THA (mean age 62.7 ±13.7 years) spent significantly more minutes in activities of moderate intensity ($P<0.05$) compared to the normative population. However, the guidelines of health-enhancing physical activity (i.e., at least 150 minutes/week of moderate intensity or more vigorous physical activity) were only met by 51.2% of THA patients and 48.8% of the normative population. This difference was influenced by gender. Women met the guidelines less frequently than men (OR 0.48, CI 0.28-0.80; $P<0.01$). Although in this study THA patients appeared to be at least as physically active as a normative population, a large percentage of these patients did not meet the guidelines.

The results suggest that more information relating to the physical activity behaviour of patients after THA is needed, including factors that may constitute specific motivators of regular physical activity among THA patients of both genders.

Assessment of physical activity behavior in THA patients

Assessment of the physical activity behavior of patients after THA can serve two important goals. First, it can provide insights with respect to patient compliance with current recommendations for health-enhancing physical activity. Second, as physical activity has been recognized as an important determinant of durability of the implanted hip prosthesis, important insights related to this aspect of hip prosthesis survival rates can be gained. Investigations in these areas can allow for a fairer and precise comparison between the results of procedures performed with different prosthetic designs and/or bearing couples.[44,77] Furthermore, information with respect to physical activity behavior may be used to optimize prosthesis wear simulator studies.[17]

Until now the main focus of outcome studies after THA has not been on physical activity but on the assessment of self-reported physical functioning, using generic and disease-specific outcome instruments such as the MOS 36-Item Short Form Health Survey (SF-36)[78] and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).[79] In fact, these instruments only provide information about the limitations patients experience and not about the amount of physical activity in which they engage.

Physical activity behavior is difficult to measure. Instruments need to be valid and reproducible, giving a detailed profile of type, duration, frequency, and intensity of the most common daily physical activities of patients after THA. They should not be too expensive (when used for large-scale studies) and be able to assess physical activity at an individual as well as at a group level. They should not affect the physical activity behavior they try to measure, and need to be acceptable to the patient and applicable in different age groups.[5] Furthermore, they should account for the variations in physical activity which may occur over time. For this reason, the activity score should be cumulative and assessed on a regular base.[44] Unfortunately, none of the instruments in use today to measure physical activity of individuals fulfills all of these criteria.

Physical activity may be assessed by direct measurements, including behavioral observation, mechanical or electronic devices, such as heart rate monitors, pedometers, motion sensors or accelerometers, and physiologic measurements such as direct and indirect calorimetry, or by self-report, including diaries, logs, recall surveys, retrospective quantitative histories and global self-reports.[5] Although direct measurements eliminate the problems of poor memory and biased self-reporting, and thus can be considered to be an objective method for assessing physical activity, their use in general is limited by high costs and the burden on participants and investigators. Furthermore, they frequently only provide information about certain aspects of physical functioning or movement and typically only can be used in a limited time-frame.

Therefore, self-report instruments continue to be the most widely used type of physical activity measure, allowing collection of data from different domains of physical activity from a large number of people at low costs. However, there are also limitations to their use. Recalling physical activity is a highly complex cognitive task and instruments can vary in their cognitive demands. Older adults in particular may have memory and recall skill limitations. In general, people tend to overestimate their physical activity level.[80]

The University of California Los Angeles activity score (UCLA) is an example of a self-reported score which is currently used by clinicians to assess physical activity after THA. The UCLA score is based on participation in the highest-rated activity, regardless of the frequency or duration of the activity. However, given its categorical nature it does not provide information with respect to physical activity in the context of health-enhancing physical activity and is therefore not suitable to assess compliance to the international recommendations of health-enhancing physical activity. Furthermore, it has not proven to be precise enough to account for the influence of age on the chance for revision.[77]

Self-report instruments which might be better suitable for these goals are the Short Questionnaire to assess physical activity (SQUASH)[75] or the International Physical Assessment Questionnaire (IPAQ).[81] Although the SQUASH may also be hampered by some of the mentioned limitations of a self-report instrument, it is short, easy to fill in and addresses several domains of habitual physical activity. It recalls activities during an average week in the past months. A main advantage of the SQUASH is that it is used nationwide in the Netherlands. Government agencies use it to monitor the physical activity level of the Dutch population. From an international perspective, an alternative to the SQUASH could be the International Physical Assessment Questionnaire (IPAQ).[81] The IPAQ was developed as an instrument for cross-national monitoring of physical activity and inactivity in order to overcome the problem of diverse physical activity questionnaires being in use, preventing international comparisons.[80] It can be hypothesized that such a questionnaire may also be useful in assessing overall physical activity levels in post THA patient samples (although, as an epidemiological instrument, the IPAQ was not developed for use in clinical settings in the first place or with respect to measuring change as a function of physical activity interventions). Active patients, reflected in higher activity score, can be expected to apply more loading cycles to their hip prosthesis than less active patients. However, it should be noted that a certain level of activity can be reached by a wide variety of activities, implying a wide variation of joint loads applied to the prosthesis. In the interpretation of a certain activity score one should account for these potential differences in joint loads. So far no gold standard for the assessment of physical activity has been determined and there is no physical activity questionnaire which has been validated in patients after THA.

CONCLUSIONS

In an aging society, the assurance of health and health-related quality of life among the growing number of older adults has to be an important goal offering key individual as well as societal benefits. One of the most important lifestyle behaviors which has been shown to preserve and promote health and function is regular physical activity. This has lead to the establishment of health-enhancing physical activity recommendations. However, currently a major portion of older adults engage in a sedentary lifestyle and do not comply with these recommendations.

An important and growing subset of the older population will consist of patients after THA. When recommending physical activity to these patients, the pros and cons of physical activity have to be carefully weighed. There are no specific physical activity recommendations for patients after THA, but it can be assumed that the recommendations of health-enhancing physical activity which have been issued for older adults also generally apply to older adults after THA. Therefore, older adults after THA should be advised to participate in regular exercise programs aimed at improving health as well as cardiorespiratory and musculoskeletal fitness, integrating preventive as well as therapeutic recommendations. For the achievement of musculoskeletal fitness, strength training typically has to be included in the exercise program. Generally, post-THA patients should be recommended to take part in low-impact, low-contact activities and avoid high-contact, high-impact activities with sudden repeated impacts and forced rotation with weight-bearing.

So far little is known about the physical activity behavior of patients after THA. Insight into this behavior is not only necessary from a health perspective, but also because it could offer more insight into the use of the prosthesis and thereby provide useful information concerning the survival of the implanted hip prosthesis. For these reasons, more attention to the recommendation and evaluation of physical activity behavior as part of outcome assessments for patients after THA is recommended.

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CHAPTER 3

Predictive value of the Western Ontario and McMaster Universities Osteoarthritis Index for the amount of physical activity after Total Hip Arthroplasty

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ABSTRACT

Background and Purpose

Despite the recognized health benefits of physical activity, little is known about the amount of physical activity that patients perform after total hip arthroplasty (THA). To this end, the ability of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) to predict the amount of physical activity that patients with a THA perform, as measured by the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH), was determined.

Subjects and Methods

Three hundred sixty-four patients who had a THA returned questionnaires. Pearson correlation coefficients were calculated between scores on the WOMAC and SQUASH. Binary logistic regression modeling was used to determine the extent to which the WOMAC score could predict that patients would meet national and international guidelines for health-enhancing physical activity.

Results

Scores on the WOMAC and SQUASH showed a significant, but low, correlation (r = .14-.24). Although the WOMAC score was a significant predictor for meeting national and international guidelines for physical activity, the odds ratio was low (1.022, 95% confidence interval=1.012-1.033) and only 6.9% of the variance could be explained (Nagelkerke r^2 =.069).

Discussion and Conclusion

The results suggest that the WOMAC is not suitable for predicting the amount of physical activity after THA, requiring the use of an additional outcome measure.

INTRODUCTION

There is a growing societal awareness of the importance of physical activity for general health. Regular physical activity has proven to be effective in the primary and secondary prevention of several chronic conditions (eg, cardiovascular disease, type-2 diabetes, colon and breast cancer, hypertension, obesity, depression, osteoporosis) and is linked to a reduction in mortality from all causes.[1-5] Regular physical activity can enhance musculoskeletal fitness and is positively associated with functional autonomy, mobility, and bone health and negatively associated with the risk for falls.[6,7] Because of these beneficial effects of physical activity, national and international guidelines have recommended 30 minutes or more of moderately intense physical activity on at least 5, but preferably all, days of the week.[8,9]

The ability to be physically active can be severely hindered by chronic conditions such as osteoarthritis (OA) of the hip. This joint disorder is one of the most prevalent age-related musculoskeletal conditions, leading to a significant impairment in patients' ability to perform activities of daily living and having a high impact on health-related quality of life.[10,11] In the 1990s, symptomatic OA of the hip was estimated to affect 0.7 to 5.5% of men, and 0.7 to 3.6% of women 55 years of age and older in the US population.[12] In 2000, these prevalence rates among the Dutch population varied between 2.45% for men and 5.0% for women.[13]

Total Hip Arthroplasty (THA) is a highly successful and widely applied treatment for advanced OA of the hip, with 202,500 primary THAs performed in the United States in 2003[14] and 22,500 performed in the Netherlands in 2005[15]; however, little is known about the amount of physical activity performed by patients after THA. Until now, outcome studies after THA have focused on the assessment of self-reported physical functioning, using generic and disease-specific outcome instruments. These instruments primarily give information about the patients' limitations, but not about their amount of physical activity. A large part of the population undergoing THA are older adults, whose functional autonomy is often threatened and whose falls may result in complications with the implanted hip prosthesis. Physical activity for the prevention of disease and enhancement of musculoskeletal fitness in this population by means of physical activity is of the utmost importance to ensure independent living.

One of the most widely used disease-specific outcome instruments in people with osteoarthritis is the Western Ontario and McMaster universities osteoarthritis index (WOMAC).[16] Although the WOMAC does not provide direct information about amount of physical activity, it can be hypothesized that when patients experience more pain, stiffness, and limitations in physical functioning, as measured by the WOMAC, this will have an adverse effect on the amount of physical activity they can perform. In this way, the WOMAC score could predict the amount of physical activity. The aims of this study, therefore, were: (1) to determine the correlation between WOMAC scores and amount of physical activity after THA and (2) to determine the ability of the WOMAC to predict whether patients will meet national and international guidelines for health-enhancing physical activity.

METHOD

Subjects

The study sample comprised 506 patients who had undergone a primary or revision THA at the University Medical Center Groningen between February 1998 and October 2003. For all patients, the operation occurred at least 1 year before this study. The total group of 506 patients consisted of 372 patients with a primary THA and 134 patients with a revision THA. Patients were sent a questionnaire with an explanatory letter.

Eventually, 71.9% (N=364) of the patients returned their questionnaire, 8.5% (N=43) responded by telephone or letter but did not fill in the questionnaire for various reasons, and 19.6% (N=99) did not respond. Analyses of the nonrespondents did not show any differences in main characteristics (age, sex, Charnley class, and comorbidity) between respondents and non-respondents.

The study was executed in accordance with the regulations of the Medical Ethical Board of University Medical Center Groningen. Patients were informed in the explanatory letter that return of the completed questionnaire would be taken as consent to participate.

Instruments

Demographic characteristics (eg, sex, age), general comorbidity, and self-reported physical functioning and amount of physical activity were assessed by means of a self-administered questionnaire. The subjects' preoperative, joint-specific comorbidity was assessed from the medical record using the Charnley classification.[17] This classification consists of three categories:

- Category A denotes patients with only one hip involved and no other condition interfering with physical activity;
- Category B denotes patients with both hips involved, but with rest of the body unimpaired and, therefore, not responsible for any defect in the ability to be physically active; and
- Category C denotes patients with some factor, such as rheumatoid arthritis or hemiplegia, contributing to failure to achieve normal locomotion.

General comorbidity was measured with a translated version of the 12-item list of Nilsdotter et al.[18] Questions were asked about conditions or body areas with problems.

The questions were multiple-choice (yes/no/don't know). To measure postoperative outcome, the Dutch-language version of the WOMAC[19] was used. The WOMAC is one of the most widely used disease-specific, health-related quality-of-life questionnaires for measuring outcome after THA.[20] It has proven to be valid, reliable, and responsive,[16,21] and the Dutch-language version has shown satisfactory cross-cultural validity.[19] Using a Likert scale, subjects rate themselves on multiple items grouped into 3 domains: pain (5 items), stiffness (2 items) and physical functioning (17 items). Each subscale is scored as a summation of items. The scores of the 3 subscales make up the total score of the WOMAC. In this study, the total score was recoded into a 100-point scale, with a higher score representing better physical functioning.

The Short Questionnaire to Assess Health-enhancing physical activity (SQUASH)[22] was used to determine amount of physical activity. The SQUASH measures habitual physical activity level and is structured in a way that allows the results to be compared with national and international physical activity guidelines. Subjects are considered to be meeting the national or international guidelines if they spent 30 minutes or more on moderately intense or vigorously intense physical activity on 5 to 7 days of the week.

The SQUASH contains questions on commuting activities, leisure-time and sports activities, household activities, and activities at work and school (Appendix). It consists of 3 main queries: days per week, average time per day, and intensity (effort). In order to keep the questionnaire short and easy to complete, intensity of household activities and activities at work and school are prestructured into 2 categories, light or intense, while time spent on activities at work and school is depicted as average time per week. Using the Ainsworth Compendium of Physical Activities,[23] activities are then assigned an intensity score, based on the reported effort in the questionnaire. This intensity score is expressed in metabolic equivalents (METs). One MET is defined as the energy expenditure for sitting quietly. Metabolic equivalents higher than 1 are activities defined as multiples of the resting metabolic rate. Activities can be subdivided into 3 intensity categories:

- Light: 2 to < 4 METs for adults and 2 to < 3 METs for older adults (age 55 and older)
- Moderate: 4 to < 6.5 METs for adults and 3 to < 5 METs, and
- Vigorous: ≥ 6.5 METs for adults and ≥ 5 METs.

Activities with a MET value lower than 2 are not included because they are considered to contribute negligibly to habitual physical activity level. A total activity score as well as activity scores for separate questions can be calculated by multiplying total minutes of activity by the intensity score.

The total activity score on the SQUASH has shown a Spearman correlation coefficient (*r*) for overall reproducibility of .58 (range=.36-.74, $p<.05$). Correlations (*r*) for the reproducibility of separate questions varied between .44 and .96, with a mean value of .75 ($p<.05$). The SQUASH has been validated using an accelerometer, showing a Spearman correlation coefficient (*r*) between accelerometer readings and total activity score of .45 (95% confidence interval=.17-.66). These values are comparable to those of other physical activity questionnaires.[22] Therefore, for the purpose of our study, we considered the scores on the SQUASH to be sufficiently reliable and valid to measure the level of physical activity of an adult population.

Data analysis

The data were analyzed using the Statistical Package for the Social Sciences (version 12) software. Descriptive statistics were used to describe the main characteristics of the sample. To determine the correlation between the total WOMAC score and the main outcomes of the SQUASH (total duration of physical activity a week and total time spent doing light, moderate, and vigorous physical activities a week), a Pearson correlation coefficient was used.

Binary logistic regression modeling was used to determine the extent to which the total score on the WOMAC can predict that a person will meet national and international guidelines for health-enhancing physical activity. In that respect, the dependent variable (meeting the guidelines) was coded as 0 (not meeting the guidelines) and 1 (meeting the guidelines). Subjects were considered to meet the guidelines if they spent 30 minutes or more on moderately or vigorously intense physical activity on 5 to 7 days of the week, as assessed by the SQUASH. The odds ratio was used to express the results of the binary logistic regression. An odds ratio of 1 indicates no association between the total score on the WOMAC and meeting the guidelines. An odds ratio >1.0 connotes a direct association and an odds ratio <1.0 indicates an inverse association of the total score on the WOMAC and meeting the guidelines. Confounding effects and effect modification of group (primary or revision THA), general comorbidity, Charnley classification, age, and sex were assessed. A p-value <.05 was considered to be statistically significant.

RESULTS

Baseline characteristics, comorbidities, and Charnley classification of the study population are shown in Table 1. The mean age of the subjects was 64.4 years, with 62.4% female subjects. A primary THA was performed in 75% of the subjects and a revision THA in 25% of the subjects.

The mean total score on the WOMAC was 71.2. The total score on the WOMAC and the subscale scores and total score on the SQUASH are reported in Table 2.

Pearson correlation coefficients were calculated between the total score on the WOMAC and the total time spent doing light, moderate, and vigorous physical activities a week, as well as the total time spent on physical activity a week. Correlations between the WOMAC

Table 1: Baseline characteristics of the study population (n=364).

Characteristics	n (%)
Age (mean ± SD)	64.4 ± 13.7
Sex, male/female	137 (37.6) / 227 (62.4)
Primary THA[a]/revision THA	273 (75) / 91 (25)
Charnley classification	
- Category A	254 (69.8)
- Category B	76 (20.9)
- Category C	34 (9.3)
General Comorbidities	
- Heart and vascular diseases	46 (12.6)
- Hypertension	105 (28.8)
- Peripheral vascular problems	8 (2.2)
- Lung problems	37 (10.2)
- Diabetes mellitus	35 (9.6)
- Neurological disease	22 (6.0)
- Any form of cancer	24 (6.6)
- Stomach ulcers	4 (1.1)
- Renal disease	8 (2.2)
- Vision problems	70 (19.2)
- Back pain	142 (39.0)
- Psychological problems	14 (3.8)

[a]THA=total hip arthroplasty.

Table 2: Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and Short Questionnaire to Assess Health-Enhancing Physical Activity (SQUASH) scores (mean±SD) (n=361-364).

Scale	Score
WOMAC total score (scale 0-100)	71.19 ± 21.62
SQUASH	
Total physical activity (min/wk)	1498.72 ± 1289.04
Light-intensity physical activity (min/wk)	948.01 ± 1022.80
Moderate-intensity physical activity (min/wk)	340.91 ± 512.77
Vigorous-intensity physical activity (min/wk)	209.79 ± 393.51

and the subscale scores and total score on the SQUASH were significant (2-tailed p<.05) and were as follows: .14 for light-intensity physical activity, .19 for moderate-intensity physical activity, .15 for vigorous-intensity physical activity, and .24 for total time spent on physical activity.

Binary logistic regression modeling was used to determine the extent to which the total score on the WOMAC (independent variable) predicted that subjects would meet national and international guidelines on health-enhancing physical activity as measured with the SQUASH (dependent variable). The results showed that the WOMAC score significantly predicts whether subjects met the guidelines (odds ratio=1.022, 95% confidence interval=1.012-1.033). This is also reflected in the Hosmer-Lemeshow goodness-of-fit statistic (χ^2=1.797, p=.987), which tests the hypothesis that the observed data are significantly different from the predicted values from the model. A nonsignificant value for this test indicates that the model predicts "real-world" data fairly well.[24] Interaction terms were not significant, indicating no effect modification or confounding effects.

DISCUSSION

Currently, the outcome after THA is considered successful when there is a marked improvement in the scores on generic or disease-specific, health-related quality-of-life outcome instruments such as the WOMAC. With respect to physical functioning, these instruments only provide information about the limitations that patients experience; however, there is a growing societal awareness of the benefits of physical activity and the negative effects of a lack of physical activity on general health. For this reason, it is important to obtain information about the amount of physical activity that patients perform after THA. Literature on this aspect of physical functioning is very sparse, however, and has focused mainly on the determination of realistic loading conditions for hip prostheses instead of the importance of physical activity for general health.[25-30] The objective of this study, therefore, was to investigate whether the score on the WOMAC could predict the amount of physical activity after a primary or revision THA.

We studied a large population with a high response rate of 71.9%. Although the correlations between the WOMAC and SQUASH were significant and the results of the logistic regression analysis showed that the total score on the WOMAC was a significant predictor of patients fulfilling national and international guidelines on physical activity, it can be concluded from the results that the clinical usefulness of the WOMAC for predicting the amount of physical activity in patients after THA is very limited. Correlations between the total score on the WOMAC and the subscale and total scores on the SQUASH varied only between .14 and .24 and, therefore, must be considered low.[31,32] Additional analysis in which we correlated the physical functioning subscale score of the WOMAC (instead of its total score) with the score on the SQUASH resulted in a correlation coefficient (r) in the same range (.26). With respect to the binary logistic regression analysis, an odds ratio of only 1.022 (95% confidence interval=1.012-1.033) was found, indicating that the score on the WOMAC is not clinically useful in predicting the fulfillment of national or international guidelines on health-enhancing physical activity. This is confirmed by the Nagelkerke r^2 of .069 for this model, which means that only 6.9% of the variance could be explained and that only 60.2% of the subjects could be classified correctly.

To our knowledge, this is the first study to investigate the ability of the WOMAC to predict the amount of physical activity that patients would perform after a primary or revision THA as assessed by the SQUASH. In the literature, we only found 2 studies in which a similar comparison was made between an instrument measuring limitations that patients experience and amount of physical activity. Morlock et al.[30] compared the Harris Hip Score (HHS) with the results of a portable activity monitoring system and found a significant correlation with only some of the activity parameters. There was a high variability in activity parameters between patients with similarly high HHS, limiting the predictive power of the HHS on activity levels. It can be concluded that these results are in line with those found in our study, reflecting a low correlation between physical functioning and amount of physical activity. This may reflect the fact that people's physical activity pattern is determined not solely by their physical abilities or inabilities, but also by demographic, social, psychological, and environmental factors.[33-35] Recently, Beaulé et al.[36] determined the relationship between patient activity level as measured by the University of California-Los Angeles (UCLA) activity score and the Harris Hip Score (HHS), as well as the 12-Item Short-Form Health Survey (SF-12). They found a strong correlation between the UCLA activity score and both the HHS and the SF-12 physical component scores, with Pearson correlation coefficients of .57 and .62. However, compared with the SQUASH, the UCLA activity score can be considered to be a less detailed estimate of physical activity. The study by Beaulé et al,[36] however, emphasizes the value of assessing patient activity as part of the outcome of THA.

In Western societies, the coming decades will show a steadily increasing demand for primary as well as revision THA.[14,37] From an individual as well as a societal perspective, it is important that these patients remain physically active after a THA, not only to improve their general health, but also to maintain their ability to live independently. The results of this study have shown that using the WOMAC to evaluate functional status postoperatively gives only information on whether patients experience limitations in their physical functioning, not on their physical activity patterns. To that end, we recommend including an additional measure that gives information about the patient's amount of physical activity. In this study we used the SQUASH. Advantages of this questionnaire are that it is self-administered and short and takes only a few minutes to complete. A shortcoming is the fact that, until now, research has only been done into its reliability and validity in an adult population that is healthy and not in a population of patients after THA. Furthermore, the reliability of the data for the SQUASH has only been determined using Spearman correlation coefficients, and it can be argued that this is an inappropriate statistic to measure reliability.[38,39] Finally, a limitation of our study is the fact that we did not test the reliability of our own data collected by means of the WOMAC and SQUASH.

The SQUASH was developed in the Netherlands and is used nationwide by

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institutions to measure the physical activity pattern of the Dutch population. From an international perspective, the International Physical Assessment Questionnaire (IPAQ)[40] may be considered to be an alternative, comparable questionnaire. The IPAQ is the result of an international attempt, supported by the World Health Organization, to standardize the measurement of physical activity internationally. There are 4 long and 4 short versions of the IPAQ, administered by telephone interview or self-administered, recalling physical activity either during the last 7 days or during a usual week. As in the SQUASH, energy expenditure is expressed in METs and scores on the IPAQ can be compared with the national and international guidelines on health-enhancing physical activity. However, no standard measure to assess physical activity after THA has been determined so far.

Conclusions

Despite the recognized benefits of regular physical activity on general health and musculoskeletal fitness, little is known about the amount of physical activity performed by patients after THA. For this reason, we determined whether the WOMAC, which is one of the most widely used disease-specific, health-related quality-of-life questionnaires for measuring outcome after THA, can be used to predict amount of physical activity performed after THA. We concluded that the WOMAC is not clinically useful for this goal, necessitating the use of additional measures.

Appendix: The Short Questionnaire to Assess Health-Enhancing Physical Activity(SQUASH) (Reprinted with permission from Wendel-Vos et al[22])

Think about an average week in the past few months. Please indicate **how many days per week** you performed the following activities, how much time **on average** you were engaged in them, and (if applicable) how strenuous this activity was for you.

COMMUTING ACTIVITIES (round trip)	days per week	average time per day	Effort (circle please)
Walking to/from work/school	....days	....hours ....minutes	slow/moderate/fast
Bicycling to/from work/school	....days	....hours ....minutes	slow/moderate/fast

Not applicable

LEISURE-TIME ACTIVITIES	days per week	average time per day	Effort (circle please)
Walking	....days	....hours .....minutes	slow/moderate/fast
Bicycling	....days	....hours .....minutes	slow/moderate/fast
Gardening	....days	....hours .....minutes	light/moderate/intense
Odd jobs	....days	....hours .....minutes	light/moderate/intense
Sports (please write down yourself) e.g., tennis, fitness, skating, swimming, dancing			
1.	....days	....hours .....minutes	light/moderate/intense
2.	....days	....hours .....minutes	light/moderate/intense
3.	....days	....hours .....minutes	light/moderate/intense
4.	....days	....hours .....minutes	light/moderate/intense

HOUSEHOLD ACTIVITIES	.....days per week	average time per day
Light household work (cooking, washing dishes, ironing, child care)	.....days	....hours ....minutes
Intense household work (scrubbing floors, carrying heavy shopping bags)	....days	....hours ....minutes

ACTIVITY AT WORK AND SCHOOL	average time per week
Light work (sitting/standing with some walking, e.g. a desk job)	....hours .....minutes
Intense work (regularly lifting heavy objects at work)	....hours ....minutes

Not applicable

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CHAPTER 4

Reliability and validity of the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) in patients after Total Hip Arthroplasty

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ABSTRACT

Background: Despite recognized benefits of regular physical activity on musculoskeletal fitness as well as general health, little is known about the physical activity behavior of patients after Total Hip Arthroplasty (THA). So far, no physical activity questionnaire has been validated in this category of patients. As the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH) has been shown to be a fairly reliable and valid tool to gauge the physical activity behavior of the general Dutch adult population, we measured the reliability and relative validity of this tool in patients after THA.

Methods: 44 patients (17 men and 27 women, mean age 71 ± 8 years) completed the SQUASH twice with an in-between period of 2 to 6 weeks (mean 3.7). Reliability was determined by calculating the Spearman correlation coefficient between the activity scores of the separate questions as well as the total activity scores from both administrations. Additionally, a Bland & Altman analysis was performed for the total activity scores. Relative validity was determined using the Actigraph™ accelerometer, worn by 39 patients (15 men and 24 women, mean age 70 ± 8 years) for a 2-week period following the second questionnaire, as a criterion measure.

Results: Spearman's correlation coefficient for overall reliability was 0.57. It varied between 0.45 and 0.90 for the separate questions. No systematic biases between readings were found. The Spearman correlation between Actigraph™ readings and total activity score was 0.67. It was 0.56 for total minutes of activity, 0.20 for time spent in light intensity activity, 0.40 for moderate activity and 0.35 for vigorous activity. Systematic bias was found between the SQUASH and the Actigraph™.

Conclusions: The SQUASH can be considered to be a fairly reliable tool to assess the physical activity behavior of patients after THA. Validity was found to be comparable with those of other questionnaires, and as it is short and easy to fill in, it may prove to be a useful tool to assess physical activity in this particular subset of the population. However, the considerable systematic bias found in this study illustrates the need for further analysis of the validity of the SQUASH.

BACKGROUND

There is a growing awareness in Western society of the importance of physical activity for general health. Regular physical activity has proven to be effective in the prevention of several chronic conditions as well as the enhancement of musculoskeletal fitness, and is linked to a reduction in all-cause mortality.[1-4] A lack of physical activity is also considered to be an important burden on public health.[5] For these reasons, national and international guidelines have been developed recommending 30 minutes or more of moderate-intensity physical activity at least five days per week, or vigorous-intensity physical activity for a minimum of 20 minutes at least three days per week.[6-8] Furthermore, every adult is advised to perform activities that maintain or increase muscular strength and endurance at least twice each week.[7] Additionally, older adults are also advised to engage in activities that maintain or increase flexibility and for those at risk for falls in exercises that maintain and improve balance.[8]

In order to assess physical activity at a population level, self-reported questionnaires are the most commonly practical tools employed.[9] The Short Questionnaire to Assess physical activity (SQUASH)[10] is an example of such a questionnaire. It was developed in the Netherlands and has been validated using an accelerometer. The scores on the SQUASH are considered to be sufficiently reliable and valid to measure the level of physical activity of a healthy adult population.[10] Nowadays it is used by government agencies to monitor physical activity of the Dutch population as well as compliance with guidelines for health-enhancing physical activity. As such, the SQUASH has provided insight into the physical activity behavior of the general Dutch adult population.

However, so far little is known about the physical activity behavior of an important and growing subset of the population: patients after total hip arthroplasty (THA). Total hip arthroplasty has become the preferred treatment for advanced osteoarthrosis of the hip and is one of the most frequently performed procedures in orthopedic surgery, with 22,500 THAs performed in the Netherlands in 2005[11] and 202,500 in the United States in 2003[12] In the coming decades these numbers are expected to increase dramatically due to the projected growth of the older population and expanding indications.[12-15]

In light of the beneficial effects of physical activity on health and musculoskeletal fitness, more insight into the physical activity behavior of patients after THA is needed. The SQUASH might be a useful tool towards providing this information. However, because it has been shown that self-reports can be inherently biased,[16] it is important to assess a questionnaire's reliability and validity for every population in which it will be used.[17] As this has not been determined in the population of patients after THA, we assessed the reliability and validity of the scores on the SQUASH as a measure of the physical activity behavior in this specific subset of the general population.

METHODS

Study population

The study population was randomly selected from a larger cohort of patients which was prospectively formed to study the physical activity behavior of patients one year after THA. This cohort consisted of patients who had undergone primary THA at University Medical Center Groningen or Martini Hospital Groningen. Selected patients were contacted by mail or phone and asked to participate in this study. From the 86 contacted patients, 44 were enrolled in the reliability study and 39 patients also in the validation study. The remaining patients were not willing to participate for various reasons. These patients did not show any differences in main characteristics (age, gender) compared to the patients in the study population. The study took place from March 2007 to September 2007. In this period we did not observe large differences in weather conditions between measurements, which could have influenced physical activity behavior.

The study was executed in accordance with the regulations of the Medical Ethical Board of University Medical Center Groningen. Written informed consent was obtained from all patients.

Study design

As part of the prospective study, all patients were sent a questionnaire with an explanatory letter one year after THA. This self-administered questionnaire contained the SQUASH as well as some demographic questions. After completion and return of the questionnaire, those patients who were enrolled in the reliability study (reliability group) completed the SQUASH for a second time 2 to 6 weeks later. This period was considered to be long enough to prevent patients from copying the SQUASH from memory, and short enough to prevent large changes in physical activity levels. Patients who also consented to participate in the validation study (validation group) wore an accelerometer, the ActiGraph™ GT1M monitor (Actigraph™, LLC, Pensacola, Florida, USA), during the two weeks following completion of the second questionnaire. These patients kept a diary in which they noted periods of noncompliance with the Actigraph and/or exceptional activities.

Physical activity questionnaire

The SQUASH was used to assess the physical activity behavior of the study population. It is structured in a way that allows comparing the results to national and international physical activity recommendations. The SQUASH contains questions on commuting activities, leisure-time and sports activities, household activities, and activities at work and school. It consists of three main queries: days per week, average time per day and intensity (effort).

In order to keep the questionnaire short and easy to fill in, intensity of household activities and activities at work and school are prestructured into two categories, light or intense, while time spent on activities at work and school is depicted in average time per week.

Calculation of the activity score per week from the SQUASH

Patients were asked to refer to an average week in the past few months. Using the Ainsworth compendium of physical activities,[18,19] activities were assigned a MET value. One MET is defined as the energy expenditure for sitting quietly. Based on the Dutch physical activity guideline,[6] activities were subdivided for adults and older adults (up to age 55 and older) respectively into three intensity categories. For adults activities with a MET-value between 2 and < 4 were classified as light, between 4 and < 6.5 as moderate, and ≥ 6.5 as vigorous intensity. For older adults activities between 2 and < 3 MET were classified as light, between 3 and < 5 MET as moderate, and ≥ 5 MET as vigorous intensity. Activities with a MET value lower than 2 were not included because they are considered to contribute negligibly to physical activity level. Based on reported effort in the questionnaire, activities were assigned an intensity score and a total activity score; activity scores for separate questions were calculated by multiplying total minutes of activity by the intensity score.

Activity monitor

Physical activity was also assessed by means of the ActiGraph™ GT1M activity monitor. This is a compact (3.8 x 3.7 x 1.8 cm), light-weight (27 gr) uniaxial accelerometer, measuring and recording time-varying accelerations ranging in magnitude from approximately 0.05 to twice gravitational acceleration. It is band-limited to a frequency range of 0.25 to 2.5 Hertz, so that normal human motion is detected and motion from other sources rejected. The ActiGraph™ collects and reports physical activity in "counts". Counts are the summation of the accelerations measured during a user-specified time interval (epoch), and represent the intensity of activity in that epoch. In this study, data were collected for each minute during a two-week period. Patients were instructed to wear the monitor during the time they were not asleep, except when showering, bathing or swimming. The monitor was firmly attached to a belt on the waist (sagittal line).

Calculation of activity from the activity monitor

Activity counts per minute were converted to MET values using the equation published by Freedson et al.[20] (MET value = 1.439008 + (0.000795 * counts/minute)), with cutoff points for the intensity categories consistent with those of the SQUASH. After this conversion, time spent per week in the different intensity categories as well as total time of activity was calculated. Furthermore, mean counts per minute were calculated by dividing the total count over two weeks by the total number of minutes the ActiGraph™ was worn. For purposes of reproducibility of this reference method, the activity level was only calculated for days in which the monitor was worn for 12 hours or longer. Assuming one sleeps for 8 hours a day, this time period represents at least 75% of the available time (16 hr). For purposes of comparability to the reference period of the SQUASH, the monitor had to be worn for at least seven days.

Statistical Analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS, Chicago) software (version 14). Descriptive statistics were used to describe the main characteristics of both study populations.

Reliability of the SQUASH was determined by calculating Spearman's correlation coefficient between the activity scores of the separate questions as well as the total activity scores from both administrations. Additionally, a Bland & Altman analysis was performed for the total activity scores.[21]

Spearman's correlation coefficients were used to determine relative (or concurrent) validity of the scores on the SQUASH using the Actigraph™ as criterion measure. To this end, the scores of the first SQUASH were used to exclude the possibility of biases resulting from an increased awareness of activity or a learning effect. Spearman's correlation coefficient was assessed between total activity score of the SQUASH and mean counts per minute of the ActiGraph™. Spearman's correlations were also assessed between total time spent in activity, as well as time spent in different intensity categories of physical activity, according to the SQUASH and the ActiGraph™. Additionally, Bland & Altman analyses were performed.

To examine the capability of the SQUASH for categorizing patients according to their physical activity level, the kappa statistic for the tertiles of both activity scores and activity counts as well as the percentage of exact agreement between the tertiles were calculated. This was also performed for the capability of the SQUASH to determine if patients complied with the guidelines of health-enhancing physical activity.

RESULTS

Demographic characteristics of the study populations are presented in Table 1. Mean age of the patients in the reliability group was 71, with 61.4% female patients. In the validation group the mean age was 70, with 61.5% females. Patients completed the SQUASH for a second time after a mean of 3.7 weeks. No technical errors were encountered during the Actigraph™ registrations.

Of the reported time (SQUASH), 46% was spent during leisure-time activities, 44% during household activities and 10% at work. Almost no time was spent on commuting

Table 1 Patient characteristics
Characteristics of the patients included in the reliability and validity group

	Reliability group *n* = 44	Validity group *n* = 39
Age (years) (mean ± SD)	71 ± 8	70 ± 8
Sex, male/female (n (%))	17 (38.6)/27 (61.4)	15 (38.5)/24 (61.5)
Body Mass Index (kg/m^2)	26.8 ± 4.5	26.7 ± 3.7
Family status (n (%))		
Alone	12 (27.3)	8 (20.5)
With Partner	32 (72.7)	31 (79.5)
Educational Level (n (%))		
Lower	14 (31.8)	12 (32.4)
Secondary	20 (45.5)	17 (43.6)
Higher	9 (20.4)	7 (18.0)
Other	1 (2.3)	1 (2.6)
Unknown		2 (5.1)
WOMAC* total score (scale 0-100) (mean ± SD)	79.8 ± 18.6	80.8 ± 16.5

**WOMAC = Western Ontario and McMaster Universities Osteoarthritis index*[27]

Table 2 Physical activity of patients in the reliability group and reliability of the SQUASH
Minutes per week spent in different categories of physical activity (mean ± SD) by patients in the reliability group, activity scores from the dual measurements (mean ± SD) and reliability of the total activity scores, as well as reliability of the scores on separate questions of the SQUASH (Spearman correlation coefficient).

Item	Minutes/week SQUASH-1 n= 44	Activity score SQUASH-1 n = 44	Activity score SQUASH-2 n = 44	Reliability $r_{Spearman}$ n = 44
All items together	1694 (1173)	7138 (5577)	5792 (4416)	0.57*
Commuting				
Walking	1 (9)	7 (45)	23 (136)	0.68*
Cycling	0 (0)	0 (0)	36 (171)	-
Activities at work				
Light	142 (488)	284 (977)	202 (564)	0.47*
Intense	27 (126)	136 (632)	68 (452)	0.70*
Household activities				
Light	709 (723)	1443 (1432)	1211 (1378)	0.72*
Intense	31 (82)	164 (425)	213 (540)	0.45*
Leisure time				
Walking	215 (303)	1048 (1515)	588 (665)	0.58*
Cycling	203 (181)	1625 (1529)	1471 (1735)	0.77*
Gardening	113 (145)	889 (1159)	882 (1510)	0.90*
Odd jobs	76 (247)	365 (1209)	345 (1016)	0.57*
Sports	177 (405)	1178 (2825)	753 (2072)	0.84*

** P≤ .01*

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activities (Table 2). Assessment of physical activity by means of the SQUASH resulted in substantially more minutes of physical activity in all intensity categories compared to the Actigraph™. Most of the time was spent at low-intensity activities, as assessed by the SQUASH (52%) as well as the Actigraph™ (80%) (Table 3).

Table 3 Results of the Bland & Altman method for validity of the SQUASH

	SQUASH-1 (*n* = 39)	Actigraph™ (*n* = 39)	*d*	SE *d*	95% CI
Total	1741± 1227	661 ± 475	1060 ± 1052	168	720 - 1400
Low intensity	898 ± 797	530 ± 337	237 ± 784	126	-17 - 491
Moderate intensity	475 ± 651	125 ± 161	238 ± 501	80	76 - 400
Vigorous intensity	368 ± 332	4 ± 9	302 ± 317	51	199 - 405

All times are expressed as minutes of activity per week (mean ± SD).
d = mean difference between time spent in physical activity as assessed by the first administered SQUASH (SQUASH-1) and the Actigraph™.
SE d = standard error of the mean difference.
95% CI = 95% confidence interval of the mean difference between the two measurements.

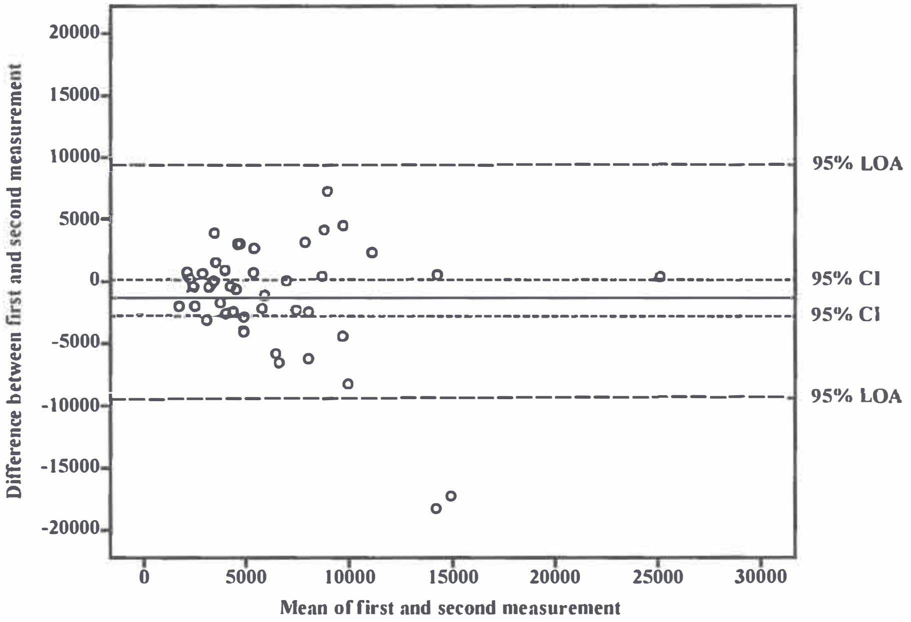

Figure 1: Bland & Altman graph with limits of agreement (LOA)
The differences between total activity scores on the first and second SQUASH, plotted against their mean for each patient, together with the 95% confidence interval (CI) and the 95% LOA. Activity score = minutes x intensity.

Reliability

Spearman's correlation coefficient for the total activity score was 0.57. Reliability for commuting bicycling activities could not be determined because only one of the patients reported this activity on the second questionnaire. For the other, separate questions the Spearman correlation coefficients ranged from 0.45 to 0.90, with a mean value of 0.61. Intense household activity was the least reliable, while gardening was the most reliable physical activity (Table 2). Reliability within the low-, moderate- and vigorous-intensity categories was 0.54, 0.55 and 0.85 respectively. Bland and Altman analysis for the total activity score showed no significant difference between the two measurements, with most observations staying at the 0 ± 1.96 SD range and within the 95% limits of agreement (Fig. 1), indicating no systematic bias between measurements.

Relative validity

Spearman's correlation coefficient between total activity score and mean counts per minute was 0.67 (P = 0.01). The Spearman's correlation coefficient between total minutes of activity as assessed by the SQUASH and the Actigraph™ was 0.56 (P = 0.01), while this coefficient was 0.20 (P = 0.22) for time spent in light intensity activities, 0.40 (P = 0.40) for

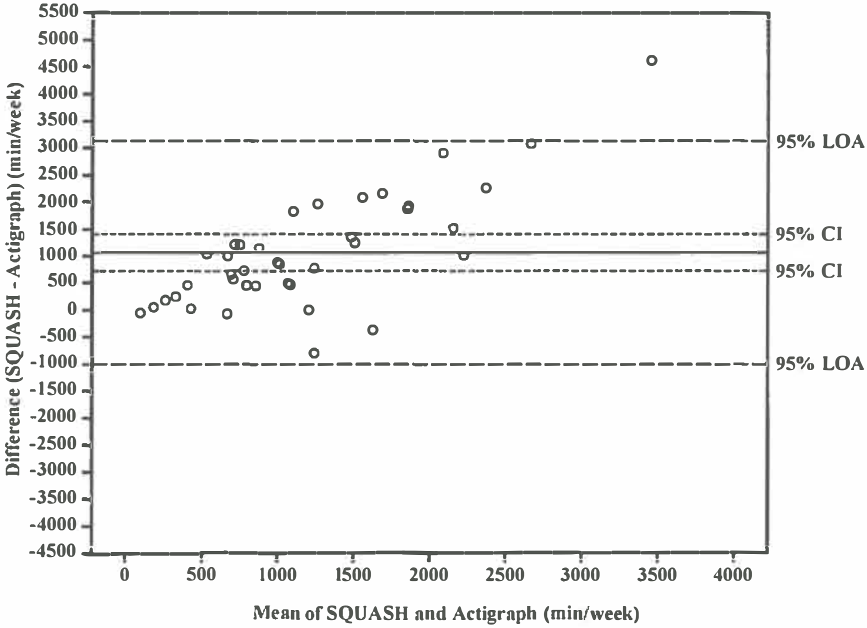

Figure 2: Bland & Altman graph with limits of agreement (LOA)
The differences between total minutes of physical activity per week as assessed by means of the SQUASH and the Actigraph™, plotted against their mean for each patient, together with the 95% confidence interval (CI) and the 95% LOA.

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time spent in moderate intensity activities and 0.35 ($P = 0.03$) for time spent in vigorous intensity activities. Bland & Altman analysis showed that the total volume of physical activity (Fig. 2), as well as time spent in moderate intensity and vigorous intensity physical activity (Table 3) was systematically higher when assessed by means of the SQUASH, compared to the ActiGraph™. Furthermore data showed heteroscedacity, which remained after log transformation.

When the tertiles of the activity scores were compared with the tertiles of the activity counts the exact agreement was 67% and the weighted kappa 0.50. With respect to compliance with the guidelines the exact agreement was 49% and the weighted kappa 0.12.

DISCUSSION

Despite recognized benefits of regular physical activity, little is known about the physical activity behavior of patients after THA. We therefore examined the measurement properties of the SQUASH as a tool to provide more insight into this behavior, as this short, self-reported physical activity questionnaire has been shown to be a fairly reliable and valid tool to assess the physical activity behavior of the general Dutch adult population.[10]

The Spearman correlation for overall reliability of the SQUASH in our study was 0.57. As, to our knowledge, this is the first study to assess the measurement properties of a physical activity questionnaire in patients after THA, we are unable to compare our results to studies in a similar population. However, this overall reliability of the SQUASH is almost identical to the reliability of 0.58 found in the study by Wendel-Vos,[10] assessing the measurement properties of the SQUASH in a population of 50 healthy adults (mean age 44 ± 6 yr). Although our study design was largely identical to that of Wendel-Vos, if we are to compare our results to those of the original study into the reliability and validity of the SQUASH it must be stated that the Wendel-Vos study differed from ours in that participants first completed the SQUASH for a second time before the Actigraph™ readings were performed. This was done to prevent a possible influence on reliability due to an increased awareness about physical activity, which might occur when the Actigraph™ is worn between the two measurements of the SQUASH. Reliability is also consistent with the reliability of other physical activity questionnaires, validated by means of an accelerometer in adult populations. In a review of seven physical activity questionnaires, validated with accelerometers in adults, reliability varied between 0.34 and 0.89.[22] Also, a study into the reliability and validity of the International Physical Activity Questionnaire (IPAQ), which is comparable to the SQUASH but was developed for cross-national monitoring of physical activity, showed a Spearman correlation coefficient for the short forms of the IPAQ ranging from 0.25 to 0.88, with a pooled reliability of 0.76.[23] The reliability found in our study is thus comparable with reliabilities found in other physical activity questionnaires. Furthermore, Bland and Altman analysis showed no systematic bias on total activity scores between test and retest.

The total activity score on the SQUASH correlated significantly with the mean activity counts per minutes measured by the Actigraph™ ($r_{Spearman}$ = 0.67). The total minutes of activity as assessed by the SQUASH and the Actigraph™ also correlated significantly ($r_{Spearman}$ = 0.56). Hence the SQUASH can explain 31% of the total variation in physical activity. When comparing the tertiles of activity scores with the tertiles of activity counts, exact agreement was 67%, which is fair to good. The weighted kappa was 0.50, representing fair agreement. The relative validity of the SQUASH in our study is higher than that found in the study by Wendel-Vos, showing a Spearman correlation coefficient between total activity score and accelerometer readings of 0.45. Comparison of the tertiles of the activity score with tertiles of the activity counts in their study showed an exact agreement of 46% and a weighted kappa of 0.30, which are lower values than those found in our study. In the Sallis review of seven physical activity questionnaires,[22] validity correlations ranged from 0.14 to 0.53. The IPAQ short forms showed validity ranging from -0.12 to 0.57, with a pooled Spearman correlation coefficient of 0.33.[23] It can therefore be concluded that the validity found in our study lies in the upper range of validity found in other questionnaires validated with an accelerometer in adult populations. However, consideration should be given to the sizeable systematic bias between the scores on the SQUASH and the Actigraph™ readings. This systematic bias may be the result of overestimating physical activity level by the SQUASH, as people tend to overestimate their physical activity level.[22] At the same time the Actigraph™ may have underestimated physical activity level. The Actigraph™ is a uniaxial accelerometer for vertical movement and is relatively insensitive to physical activities that require little vertical movement. When positioned on the waist activities such as cycling or activities involving large upper-body movement may be underestimated. Additionally, the accelerometer is not waterproof and therefore cannot be worn during activities such as swimming. Since in our study 21% of patients reported swimming and 77% cycling as part of leisure-time activities, this will have led to an underestimation of physical activity by the Actigraph™. The systematic bias may also reflect true variations in participants' physical activity levels. Since the SQUASH asks patients to recall physical activity during an average week in the past months, this timeframe was not identical to the period of time used to acquire the accelerometer data. Furthermore, to estimate the energy expenditure spent in physical activity the activity counts as obtained by the Actigraph™ have to be transformed into MET values. To do this, regression equations have been developed from studies under laboratory as well as field conditions.[20,24,25] In line with the study of Wendel-Vos we used the Freedson equation to transform activity counts into MET values. As this regression equation was developed under laboratory conditions, it may not be valid under the "field conditions" of our study as it particularly has been shown to underestimate moderate-intensity activity.[26] Additionally, the regression equation was developed in adults and may not be appropriate for older adults. However, to our knowledge, there are no regression equations specifically for older adults. This may be another factor accounting for the differences found in our study in terms of time spent in the different intensity categories between the physical activity questionnaire and the accelerometer.

CONCLUSIONS

The SQUASH can be considered to be a fairly reliable tool to assess the physical activity behavior of patients after primary THA, while the validity is comparable to those of other physical activity questionnaires. As it is short and easy to fill in, it can be used to assess the physical activity of patients after primary THA with minimal cost and burden to the subjects. However, using the Actigraph™ as a criterion measure considerable systematic bias was found between the scores on the SQUASH and the Actigraph™ readings. Therefore more research is needed to assess the validity of the SQUASH using other objective criteria and cut-points appropriate for the population under study.

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CHAPTER 5

Habitual physical activity behavior of patients after Primary Total Hip Arthroplasty

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Abstract

Background and Purpose: Despite recognized health benefits of physical activity, little is known about the habitual physical activity behavior of patients after total hip arthroplasty (THA). The purpose of this study was to analyze this behavior and the fulfillment of guidelines for health-enhancing physical activity of these patients compared with a normative population.

Subjects and Methods: The participants were 273 patients who had undergone a primary THA (minimum of 1 year postoperatively). Comparisons were made between this group and 273 age- and sex-matched individuals from a normative population. Comparisons also were made between participants with THA under 65 years of age and those 65 years of age and older and among participants with THA in different Charnley classes. Level of physical activity was assessed with the Short QUestionnaire to ASsess Health-enhancing physical activity (SQUASH).

Results: No significant differences in total amount of physical activity or time spent in different categories of physical activity were found between the THA group and the normative group. Participants with THA spent significantly more minutes in activities of moderate intensity compared with the normative group. Participants with THA who were under 65 years of age were significantly more active than older participants with THA. Charnley class had significant effects on time spent at work, time spent in moderate-intensity activities, and total amount of activity, with the least activity performed by participants in Charnley class C. The guidelines were met by 51.2% of the participants with THA and 48.8% of the normative population. Female participants met the guidelines less frequently than male participants in both the combined group (odds ratio=0.50, 95% confidence interval=0.35-0.72, $p<.001$) and the THA group (odds ratio=0.48, 95% confidence interval=0.28-0.80, $p=.001$).

Discussion and Conclusion: The results suggest that patients after THA are at least as physically active as a normative population. Nevertheless, a large percentage of these patients do not meet the guidelines; therefore, they need to be stimulated to become more physically active.

Introduction

Osteoarthrosis of the hip is one of the most prevalent age-related chronic conditions. It causes a significant impairment in patients' ability to perform activities of daily living and has a high impact on quality of life.[1,2] In cases of advanced osteoarthrosis, total hip arthroplasty (THA) has emerged as a highly successful treatment. As a result, a total of 22,453 primary THAs were performed in the Netherlands in 2005,[3] and 202,500 primary THAs were performed in the United States in 2003.[4] Due to projected growth of the older population and changing thresholds for surgery, these numbers are expected to increase dramatically in the coming decades.[4-7]

The success of THA is determined not only by its cost effectiveness[8-10] and excellent long-term prosthetic survival rates,[11] but above all by its ability to significantly improve the quality of life of patients by relieving pain and improving physical functioning.[12] With respect to physical functioning, the main focus of outcome studies after THA until now has been on the assessment of self-reported physical functioning, using generic and disease-specific outcome instruments such as the Medical Outcome Study 36-Item Short Form Health Survey (SF-36)[13] and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).[14] These instruments, however, give only information about the limitations that patients experience, not about their level of physical activity.

There is growing awareness in society of the importance of physical activity for general health. Regular physical activity has proven to be effective in the primary and secondary prevention of several chronic conditions and is linked to a reduction in all-cause mortality.[15,16] Regular physical activity also can enhance musculoskeletal fitness, which is positively associated with functional autonomy, mobility and bone health and negatively associated with the risk for falls.[17,18] These effects on musculoskeletal fitness are particularly important for patients after THA, for whom falls can result in complications with the implanted hip prosthesis, causing a more or less prolonged period of functional dependency.

In the face of these beneficial effects, Dutch and international guidelines have been developed for levels of health-enhancing physical activity. These guidelines originally recommended 30 minutes or more of moderate to intense physical activity 5 days per week, preferably daily.[19,20] Very recently these guidelines were updated, now recommending 30 minutes or more of moderate-intensity aerobic (endurance) physical activity at least 5 days per week or vigorous-intensity aerobic physical activity for a minimum of 20 minutes at least 3 days per week. Combinations of moderate- and vigorous-intensity activity also can be performed to meet the recommendation.[21,22]

Despite these developments, little is known about the habitual physical activity behavior of patients after a THA, and it is unknown to what extent these patients adhere to the guidelines of health-enhancing physical activity. Literature on the topic is scarce and fragmentary, and predominantly pertains to sports and walking activities.[23-30] So far, the main focus of these studies of physical activity of patients after THA has been on the determination of realistic loading conditions for hip prostheses and the implications of certain activities for implant survival, as well as on the return to specific activities after THA.

Until now, level of physical activity has been determined only by means of categorical scoring tools such as the 10-point UCLA activity score[31] and the 6-point Grimby scale,[32] with a score of 1 on both scales indicating hardly any to no physical activity, a score of 10 on the UCLA activity score indicating regular participation in impact sports, and a score of 6 on the Grimby scale indicating regular, vigorous activity. However, these scoring tools do not provide detailed information on duration, frequency and energy expenditure of activities performed by patients with THA. Bauman et al,[33] in a study of patients with total joint replacements (mean age=66.4 years, SD=9.4) found a mean UCLA activity score of 6, corresponding to a moderate-intensity level of physical activity, in 170 patients after primary THA, at a mean follow-up of 40.7 months. Beaulé et al[34] evaluated 152 patients with THA (mean age=58.7 years, range=21-87) with a mean follow-up of 5.2 years (range 2-21) and found a mean UCLA score of 6.8. Using the Grimby scale, Chatterji et al,[29] in a study population of 216 patients with THA (mean age=67.8 years, SD=10.2) found a light- to moderate-intensity level of physical activity (mean score=3.46, SD=1.21) 1 to 2 years postoperatively.

As none of these studies provided detailed insight into the habitual physical activity behavior of patients after a primary THA or addressed this behavior within the context of current health-enhancing physical activity recommendations, we conducted an exploratory study into the habitual physical activity behavior of these patients and compared the results with data from a normative population. Additionally, analyses comparing patients with THA younger than 65 years of age with those 65 years of age and over were performed, as well as analyses between patients with and without additional functional impairments. Finally, patient fulfillment of Dutch and international guidelines for health-enhancing physical activity, as well as the predictors of fulfillment for these guidelines, were assessed.

Method

Participants

The study sample comprised 371 patients who had undergone a primary THA at University Medical Center Groningen between February 1998 and October 2003 because of primary or secondary osteoarthrosis of the hip. All patients who had undergone a primary THA for these indications during this period were included in the study, with the exception of patients who had died at the time of follow-up. Surgeries were performed by 8 staff surgeons or under direct supervision of one of these staff surgeons. For all patients, the operation had been performed at least 1 year before enrollment in this study (mean=39 months, range=17-78), as 1 year after THA patients were considered to be beyond the recovery phase of the operation. In case of bilateral THAs, the time of follow-up was calculated from the last procedure performed. No bilateral THAs were performed at the same time. A questionnaire and an explanatory letter were sent to all patients. After 3 weeks, a reminder was sent to patients who had not replied by that time. The initial response to the first mailing was 65.2% (n=242), and eventually 73.6% (n=273) of the patients returned their questionnaire, while 7.3% (n=27) responded by phone or by letter but did not fill in the questionnaire for various reasons and 19.1% (n=71) did not respond at all. Nonresponse analysis did not show any significant differences in main characteristics (age, sex, Charnley class, and comorbidity) between respondents and non-respondents (Tab. 1).

The normative population was formed by an age- and sex-matched sample of people from the same geographic region as the study population. Data concerning this normative population were collected by the Groningen Municipal Public Health Service as part of a population survey. Every participant with a primary THA was matched with the first-appearing "healthy" counterpart of the same age and sex in the list of individuals in the normative population.

Participants were informed in the explanatory letter that return of the completed questionnaire would be regarded as consent to participate.

5

Instruments

Age, sex, general comorbidity, and level of physical activity were assessed by means of a self-administered questionnaire. Preoperative, joint-specific comorbidity of the patients with THA was assessed from their medical records using the Charnley classification.[35] This classification consists of three categories: (1) category A denotes a patient with involvement of only one hip and no other condition interfering with physical activity; (2) category B denotes a patient with involvement of both hips but the rest of the body normal and, therefore, not responsible for any defect in the ability to be physically active; and (3) category C denotes a patient with some condition, such as rheumatoid arthritis or hemiplegia, contributing to failure to achieve normal locomotion.

General comorbidity was assessed with a Dutch version of the 12-item list from Nilsdotter et al.[36] Questions were asked about the presence of 12 comorbid conditions or body areas with problems (heart, hypertension, peripheral arteries, lung, diabetes, neurological problems, cancer, ulcer, kidney disease, vision, back pain, and psychiatric disease). The questions were multiple choice (yes/no/don't know). At the end, a sum score of reported comorbidity was determined for each participant. A score of 0 indicates absence of comorbid conditions and no body areas with problems, and the maximum score of 12 indicates that the patient has all of the assessed conditions and has problems in all of the assessed body areas.

The Short QUestionnaire to ASsess Health-enhancing physical activity (SQUASH)[37] was used to determine amount of physical activity. It measures habitual physical activity level and is structured in a way that allows comparison of the results with Dutch and international physical activity guidelines. Participants were considered to be meeting the guidelines if they spent 30 minutes or more on moderately intense or vigorously intense physical activity at least 5 days a week, as this study was conducted before the updated 2007 guidelines for health-enhancing physical activity were issued. The SQUASH contains questions on commuting activities, leisure-time and sports activities, household activities, and activities at work and school. It consists of three main queries: days per week, average time per day and intensity (effort). Using the Ainsworth compendium of physical activities,[38] reported activities are assigned a metabolic equivalent (MET) value. One MET is defined as the energy expenditure for sitting quietly, and activities with MET values higher than 1 are defined as having multiples of resting metabolic rate. Subsequently, activities are subdivided into 3 intensity categories: light, moderate, and vigorous. Cutoff points for intensity categories are based on the Dutch physical activity guideline,[20] which is derived from international physical activity guidelines.[19] For adults (aged 54 years and younger), activities with a MET value of 2 to <4 are classified as those of light intensity, activities with a MET value of 4 to <6.5 are classified as those of moderate intensity, and activities with a MET value ≥6.5 are classified as those of vigorous intensity. For older adults (aged 55 years and older), activities with a MET value of 2 to <3 are classified as those of light intensity, activities with a MET value of 3 to <5 are classified as those of moderate intensity, and activities with a MET value of ≥5 are classified as those of vigorous intensity. Activities with a MET value lower than 2 are not included because they are considered to contribute negligibly to the habitual activity level. Accounting for the reported effort with which a certain activity is performed, activities then are assigned an intensity score, which is used to calculate an activity score. Activity scores for separate questions are calculated by multiplying total minutes of activity by the intensity score, and the total activity score is calculated by summing the activity scores for separate questions.

The measurement properties of the SQUASH have been assessed in a group of adults (mean age=44 years) by Wendel-Vos et al[37] and recently in our department in a group of older adults (mean age=71 years) after primary THA (unpublished research). In the group of adults in the study by Wendel-Vos et al, Spearman correlations showed an overall reproducibility of .58 for the SQUASH, whereas correlations for the reproducibility of separate questions varied between .44 and .96 with a mean value of .75 ($p < 0.05$). Using an accelerometer as an activity monitor, the Spearman correlation coefficient between accelerometer readings and total activity score was .45. In our group of older adults after THA, Spearman correlations showed an overall reproducibility of .57, whereas correlations for the reproducibility of separate questions varied between .45 and .90 with a mean value of .61 ($p < .05$). The Spearman correlation coefficient between accelerometer readings and total activity score was .67. These results are in line with those found in other studies into the reproducibility and validity of physical activity questionnaires.[39,40] Therefore, for the purpose of the current study, we considered the SQUASH to be sufficiently reliable and valid to measure the level of physical activity of adults younger than 65 years of age and adults 65 years of age and over.

Data analysis

Statistical analyses were performed using Statistical Package for the Social Sciences version 12 software (SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606). Descriptive statistics were used to describe the main characteristics of the sample. The Student *t* test was used to compare continuous variables, and the chi-square test was used to compare categorical variables. A Mann-Whitney *U* test was used for comparison of differences in activities of daily living and the intensity of those activities between the THA and normative groups, as well as between participants with THA younger than 65 years of age and those 65 years of age and over. Kruskal-Wallis testing was used to compare these differences in activities and intensities among participants within different Charnley classes. Differences between the THA and normative groups in meeting the guidelines were assessed with a chi-square test. To gain insight into the predictors of meeting Dutch and international guidelines, a binary logistic regression was used. A p value < .05 was considered statistically significant.

Results

The main characteristics of the THA and normative group are shown in Table 1. The participants in the THA group had a mean age of 62.7 years (SD=13.7), and the individuals in the normative group had a mean age of 62.4 years (SD=14.1). The percentage of women was 60.8% in both groups. There was no significant difference in comorbidity between the groups (p=.33).

An overview of physical activities in the daily lives of participants in the THA group and in the normative group is presented in Table 2. Although the total minutes of physical activity was higher in the THA group compared with the normative group, mainly due to the participants with a primary THA spending more time in leisure-time activity, this difference was not significant. There also were no significant differences with respect to the other categories of physical activity between the THA and normative groups. In all groups, most

Table 1: Main characteristics of participants who had undergone primary total hip arthroplasty (THA) (University Medical Center Groningen, 1998-2003), the normative population and nonrespondents Student *t* test was used for comparison of continuous variables. Chi-square test was used for comparison of categorical variables. A *p* value of <.05 was considered statistically significant.

Variable	Primary THA (n=273)	Normative Population (n=273)	p^a	Nonrespondents (n=15)	p^b
Age (y), mean (SD)	62.7 (13.7)	62.4 (14.1)		60.5(13.8)	.74
Sex, N (%)					.43
Male	107 (39.2)	107 (39.2)		5 (33.3)	
Female	166 (60.8)	166 (60.8)		10(66.7)	
Charnley class, N (%)					.32
category A	193 (70.7)			8(53.3)	
category B	56 (20.4)			2(13.3)	
category C	24 (8.8)			5(33.3)	
Comorbidity, mean (SD)	1.11 (1.16)	1.01 (1.22)	.72	1.07(0.96)	.56

[a]P-value for difference between patients in norm population and patients after primary THA.
[b]P-value for difference between non respondents and patients after primary THA

Table 2: Overview of physical activities in the daily life of participants who had undergone primary total hip arthroplasty (THA) (University Medical Center Groningen, 1998-2003) and in the normative population

variable	Primary THA (n=273)	Normative Population (n=273)	*p*
Activities at work	379.6 (774.5)	349.0 (805.3)	.28
Activities to/from work	28.2 (115.5)	21.2 (130.3)	.74
Household activities	642.6 (813.1)	645.9 (886.5)	.86
Leisure-time activities	550.8 (691.5)	485.6 (808.4)	.08
Sports activities	48.9 (119.5)	62.8 (206.8)	.14
Total	1,601.0 (1,326.8)	1,501.6 (1,528.3)	.09

Mann-Whitney *U* test was used for comparison of physical activity between groups. A p value <.05 was considered statistically significant. Values are expressed as mean minutes per week (SD).

of the physical activity time was spent doing household and leisure activities.

In order to get an impression of the intensity of the physical activities using the previously described cutoff points for intensity categories, activities were subdivided into 3 intensity categories: light, moderate and vigorous activity. An overview of the time (in minutes per week) spent in each of the categories is shown in the Figure. The division of activity intensities was almost equal between the THA and normative groups. However, the THA group tended to spend more minutes in activities of light intensity (*p*=.20) and fewer minutes in activities of vigorous intensity (*p*=.77) compared with the normative group, while spending significantly more time in activities of moderate intensity compared with the normative group (*p*=.045).

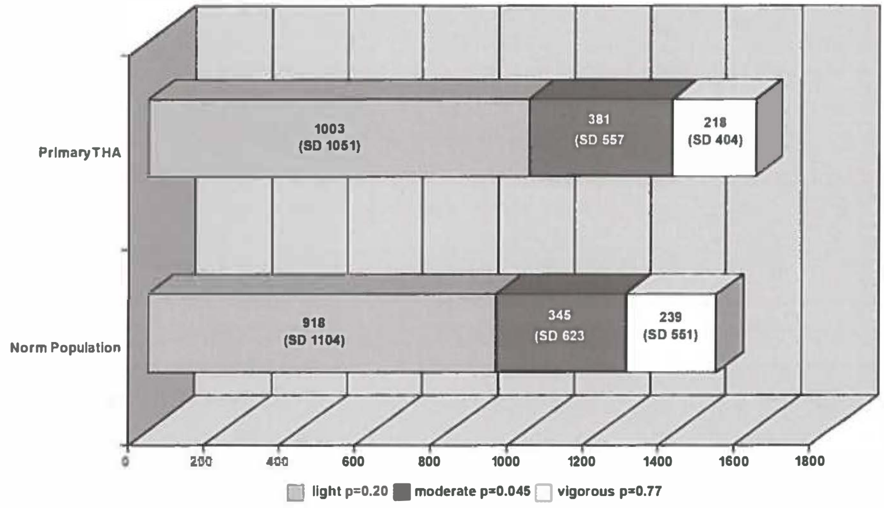

Figure : Intensity of physical activity performed by participants who had undergone primary total hip arthroplasty (THA) (University Medical Center Groningen, 1998-2003) and a normative population. Values are expressed as minutes per week (SD). A p value <.05 was considered statistically significant.

To assess the potential influence of age or additional functional impairments on physical activity level, subanalyses were performed comparing participants with THA younger than 65 years with those aged 65 years and older, as well as comparing participants with THA in different Charnley classes. The results of the subanalysis comparing the 2 age groups of participants with THA are shown in Table 3. In the older age group, there were significantly more women and the number of comorbidities was significantly higher. In both age groups, most of the time was spent in household and leisure-time activities. Participants in the younger age group also spent a large part of time at work. Compared with the younger age group, the older participants with THA were significantly less active in all types of physical activity, in activities of light and moderate intensity, and in overall physical activity.

Comparison of physical activity among participants with THA in different Charnley classes showed significant differences only in time spent at work, time spent in moderate- intensity activities, and total time spent in physical activity, with the least activity performed by those in Charnley class C (Tab. 4).

Table 3: Main characteristics and overview of physical activities in daily life of participants with primary total hip arthroplasty (THA) who were younger than 65 years of age and those who were 65 years of age and older (University Medical Center Groningen, 1998-2003)

	[illegible] (n=146)	Participants $\geq$ 65 y (n=127)	*p*
Age (y), mean (SD)	52.6 (1.0)	74.3 (5.9)	
Sex, N(%)			*.00**
Male	70 (47.9)	37 (29.1)	
Female	76 (52.1)	90 (70.9)	
Charnley class, N(%)			*.05*
Category A	112 (76.7)	81 (63.8)	
Category B	25 (17.1)	31 (24.4)	
Category C	9 (6.2)	15 (11.8)	
Comorbidity, mean (SD)	0.88 (0.99)	1.39 (1.29)	*.01**
Activities at work	631.4 (913.5)	90.0 (420.2)	.00*
Activities to/from work	41.8 (115.8)	12.5 (113.5)	.00*
Household activities	730.9 (851.5)	540.9 (757.3)	.02*
Leisure-time activities	647.2 (737.6)	439.9 (618.9)	.00*
Sports activities	57.0 (131.3)	39.5 (104.1)	.09
Activity intensity			
Light	1346.2 (1112.8)	607.7 (814.4)	.00*
Moderate	511.2 (670.1)	231.1 (333.6)	.00*
Vigorous	194.0 (334.5)	244.6 (471.1)	.70
Total	2051.3 (1338.31)	1083.4 (1110.7)	.00*

Student *t* test was used for comparison of continuous variables. Chi-square test was used for comparison of categorical variables. Mann-Whitney *U* test was used for comparison of physical activity between groups. A p value <.05 was considered statistically significant (asterisk denotes statistically significant p value). Values for activities and activity intensity are expressed as mean minutes per week (SD).

Finally, we analyzed to what extent Dutch and international guidelines were met. The percentage of participants after a primary THA who met these guidelines was 51.2% (n=140), compared with 48.8% (n=133) of the normative population. These percentages do not differ significantly (*p* = .30). Additionally, binary logistic regression analysis was used to determine the predictors of meeting Dutch and international guidelines. The dependent variable was meeting the guidelines ("yes" or "no"). The independent variables were age, sex, and total number of comorbidities for the THA and normative groups combined. For the binary logistic regression analysis of the THA group, the Charnley category was added as an additional independent variable. These independent variables were entered into the analysis because we hypothesized that they could influence the chance of meeting the guidelines. When all of these variables were entered into the regression model, we found that sex was the only variable that significantly influenced the chance of meeting Dutch and international guidelines in both the combined groups (odds ratio=0.50, 95% confidence interval=0.35-0.72, *p*<.001) and the THA group (odds ratio=0.48, 95% confidence interval=0.28-0.80, *p*=.001). The odds of men meeting the guidelines was about twice the odds of women meeting them.

Table 4: Main characteristics and overview of physical activities in daily life of participants who had undergone primary total hip arthroplasty (THA) in Charnley classes A, B and C (University Medical Center Groningen, 1998-2003)

	Charnley Class A (n=193)	Charnley Class B (n=56)	Charnley Class C (n=24)	*p*
Age (y), mean (SD)	61.6 (13.8)	64.08 (13.0)	68.08 (13.7)	0.06
Sex, N(%)				0.03*
Male	84 (43.5)	19 (33.9)	4 (16.7)	
Female	109 (56.5)	37 (66.1)	20 (83.3)	
Comorbidity, mean (SD)	1.08 (1.08)	1.06 (1.35)	1.5 (1.34)	0.16
Activities at work	436.2 (806.3)	306.4 (775.4)	95.0 (322.3)	0.04*
Activities to/from work	30.7 (102.2)	31.6 (170.6)	0.00 (0.00)	0.10
Household activities	623.5 (748.6)	732.3 (998.5)	586.3 (854.7)	0.62
Leisure-time activities	585.5 (709.5)	507.6 (684.8)	372.7 (533.2)	0.11
Sports activities	54.8 (131.2)	44.7 (95.6)	10.6 (37.7)	0.13
Activity intensity				
Light	1,024.8 (1,012.6)	1,077.1 (1,221.3)	650.8 (881.9)	0.19
Moderate	414.5 (587.8)	333.8 (508.9)	220.0 (355.6)	0.04*
Vigorous	236.5 (441.2)	167.1 (242.8)	183.1 (390.6)	0.29
Total	1,675.8 (1,292.1)	1,578.0 (1,438.88)	1,054.0 (1,223.9)	0.04*

Student *t* test was used for comparison of continuous variables. Chi-square test was used for comparison of categorical variables. Kruskal-Wallis test was used for comparison of physical activity between groups. A p value <.05 was considered statistically significant (asterisk denotes statistically significant p value). Values for activity and activity intensity are expressed as mean minutes per week (SD).

Discussion

Despite the recognized benefits of physical activity on general health, little is known about the habitual physical activity behavior of patients after THA. Therefore, we investigated this behavior by assessing frequency, duration, intensity, and total volume of time spent in several domains of everyday physical activity by patients after primary THA. In this way, the study gives a first impression of the habitual physical activity behavior of these patients. We also assessed the extent to which Dutch and international guidelines of health-enhancing physical activity were met. To our knowledge, this is the first study that systematically examines these aspects of habitual physical activity behavior after THA.

So far, outcome studies of patients who have undergone THA have shown a substantial and long-lasting improvement in health-related quality of life, with physical functioning scores approaching, reaching, or even exceeding population norms.[41-45] Our results showed that, despite a major surgical procedure, the participants with primary THA reached reached population norms with respect to level of physical activity. There was even a tendency for the total number of minutes spent in physical activity by the participants with THA to be higher than that of the normative population. This was largely caused by the number of minutes spent in leisure-time activities. Although we were not informed about the preoperative physical activity level of the participants with THA, the surgical procedure did not appear to hamper them in being as physically active as the normative population.

With respect to intensity of physical activity, the participants with THA spent more time in activities of light and moderate intensity than the normative population, while the latter tended to spend more time in vigorous activities. Only the difference in moderate-intensity activities was significant. After a THA, patients are instructed to avoid vigorous activities so as to prevent wear of the hip prosthesis through excessive activity, and-in that sense-this difference in intensity of physical activity should be considered a good and desired effect of the postoperative instructions.

As might be expected, participants with THA younger than 65 years of age were significantly more active than those aged 65 years and older. This result is in line with the findings of previous studies that assessed the walking activity of patients after THA. Patients younger than 60 years of age were found to walk 30% more than those aged 60 years and older.[25,26] In addition, men were generally found to walk more than women. Thus, when interpreting results, it is important to consider the significant differences associated with sex as well as number of comorbidities between groups, which may have had a confounding effect. Comparison of physical activity between participants with THA in different Charnley classes showed significant differences in total amount of physical activity, time spent in moderate-intensity activity, and time spent at work, with the least activity performed by patients in Charnley class C. The participants with THA in Charnley class C, however, tended to be older than those in the other Charnley classes, and there were significant differences in sex among participants with THA in the different Charnley classes, which again might have had confounding effects.

The participants with primary THA met the guidelines of health-enhancing physical activity to the same extent as the normative population. They fulfilled the norm even more frequently than the normative population. Male sex increased the odds of meeting the guidelines.

Although our study is characterized by a high response rate of 73.5% in the group with primary THA, it does have some limitations. To assess level of physical activity we used a self-administered recall questionnaire. Although self-report instruments continue to be the most widely used type of physical activity measure, allowing collection of data from different domains of physical activity from a large number of people at low costs, there are limitations to their use. Recalling physical activity is a highly complex cognitive task, and instruments can vary in their cognitive demands. Although older adults, in particular, may have memory and recall skill limitations, we have found the measurement properties of the SQUASH in a population of older adults to be identical to those in a group of younger adults (unpublished research). People tend to overestimate their physical activity level.[39]

The cross-sectional design did not allow us to assess the habitual physical activity behavior of the participants with THA preoperatively. It also was not possible to determine the changes in physical activity in the course of time after THA.

Our study presents the physical activity behavior of a group of patients who underwent primary THA in a single university medical center, by a single group of surgeons. This may limit the generalizability of these results, and further studies from other hospitals will be needed to gain more insight into the habitual physical activity behavior of patients after THA.

A main advantage of the SQUASH is that it is used nationwide in the Netherlands. Government agencies use it to monitor the physical activity level of the Dutch population. From an international perspective, an alternative for the SQUASH could be the International Physical Assessment Questionnaire (IPAQ).[40] The IPAQ was developed as an instrument for cross-national monitoring of physical activity and inactivity in order to overcome the problem of using diverse physical activity questionnaires, which prevented international comparisons.[39]

In Western societies, there will likely be a steadily increasing demand for primary THA in the coming decades.[4,6] From an individual perspective as well as from a societal perspective, it is important that these patients remain physically active after the procedure, not only to improve their general health but also their ability to live independently. Although our study has shown that patients with a primary THA behave like a normative population when it comes to fulfilling guidelines of health-enhancing physical activity, it also showed that a large percentage of these patients are not physically active enough. This finding signifies a need to stimulate such inactive patients to become physically more active. The postoperative rehabilitation phase offers an excellent opportunity to encourage patients to become physically active. In our opinion, more emphasis on the beneficial aspects of physical activity in this group of patients is justified. Based on recommendations for athletic activity after THA, patients should be advised to take part in low-impact, low-contact activities and to avoid high-contact, high-impact activities with sudden, repeated impacts and forced rotation with weight-bearing in order to decrease the risk of wear and early loosening of the prosthesis or the occurrence of dislocation or periprosthetic fracture.[46-49]

Conclusions

This study showed that patients after THA appear to be at least as physically active as individuals in the normative population. Although this finding may be considered to be another success of modern THA, it also illustrates that a large number of patients after THA are stille insufficiently physically active. In view of the many beneficial effects of regular physical activity, these patients need to be stimulated to become more physically active.

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CHAPTER 6

Physical activity behavior after Total Hip Arthroplasty (THA): a prediction based on patient characteristics.

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ABSTRACT

Objective: To determine to what extent aspects of patient characteristics (age, gender, family status, education and comorbidity) are predictive for the level of physical activity of persons with a THA.

Methods: A cross-sectional study including 372 patients. Demographics, comorbidity and physical activity behavior were assessed by means of a questionnaire and from medical records. Linear regression analysis was used to determine to what extent patient characteristics are predictive of level of physical activity. Binary logistic regression modelling was used to determine the extent to which patient characteristics are predictive in meeting international guidelines on health-enhancing physical activity.

Results: Age, education and family status significantly predict level of physical activity ($R^2 = 0.19$). Only gender significantly predicts meeting international guidelines on health-enhancing physical activity (OR = 2.06, 95% CI 1.20-3.54).

Conclusion: Patients at risk can be identified by means of patient characteristics. Increasing age, lower education and living alone are associated with a physically inactive lifestyle.

Practice Implications: Health care workers involved in the treatment of THA patients should lay an emphasis on the beneficial aspects of physical activity.

INTRODUCTION

In the coming decades, Western society will be facing a sharp increase in the number of older adults. In the United States, the number of inhabitants aged over 60 is projected to rise from 49,850,000 in 2005 (16.6%) to 107,741,000 (26.8%) in 2050 and in the Netherlands from 3,146,000 (19.3%) to 5,291,000 (30.7%).[1] This development will be accompanied by a dramatic increase in the occurrence of age-related chronic conditions such as osteoarthritis (OA). As OA is the most common indication for Total Hip Arthroplasty (THA), an increase will also be seen in the demand for THAs.[2]

Aging is associated with declining fitness and health. A distinction can be made between primary and secondary aging. Primary aging refers to changes due to the aging process itself; these changes are irreversible. Secondary aging refers to changes caused by illnesses correlated with age; such changes may be reversible or preventable. Lifestyle behaviors such as physical activity influence secondary aging.[3] Regular physical activity has been consistently and reliably linked to improvement of health and fitness.[4] However, 73.8% of American older adults aged over 65 and 36% of Dutch older adults aged over 55 can be considered physically inactive.[5,6] With respect to THA patients, little is known about their physical activity pattern. Pilot research at our department showed that THA patients do not differ significantly from a norm population [unpublished data].

In the general population, physical activity behavior is known to be influenced by a large variety of determinants such as demographics and psychological variables.[7] Among persons after a THA, however, these associations have never been a topic of research. The aim of this study is to determine to what extent aspects of patient characteristics (age, gender, family status, education, general comorbidity and joint-specific comorbidity) are predictive for the level of physical activity of persons after a THA.

MATERIAL AND METHODS

Patients

A cross-sectional study including 372 patients who had undergone a primary THA at University Medical Center Groningen between February 1998 and October 2003. The operation took place at least one year before this study. Patients were sent a self-reported questionnaire with an explanatory letter. Eventually 73.5% (N=273) returned their questionnaire, 7.4% (N=27) responded by phone or mail but did not fill in the questionnaire for various reasons, and 19.1% (N=71) did not respond at all. Non-response analysis did not show differences in main characteristics (age, gender, Charnley classification and comorbidity) between respondents and non-respondents.

The study was executed in accordance with the regulations of the Medical Ethics

Board of University Medical Center Groningen. Return of the completed questionnaire was taken as written consent to participate.

Instruments

Patient characteristics, education, comorbidity and physical activity were assessed by means of a self-administered questionnaire.

Preoperative joint-specific comorbidity was assessed from the medical record using the Charnley classification.[8] General comorbidity was measured with the 12-item list from Nilsdotter.[9]

The Short QUestionnaire to ASsess Health-enhancing physical activity (SQUASH)[10] was used to measure physical activity. The SQUASH measures habitual physical activity level and is structured in a way that allows comparing the results to international physical activity guidelines. The questions are prestructured into activities at work, activities to/from work, household activities, leisure-time activities and sports activities. With the help of the Ainsworth compendium of physical activities one subdivides activities into three intensity categories for older adults aged 55 or older: 2 to 3 MET (light), 3 to 5 MET (moderate), and 5 MET or more (vigorous).[11] Activities with a MET value lower than 2 are not included because they are considered to contribute negligibly to habitual activity level. Spearman correlation has shown an overall reproducibility of 0.58 ($p<0.05$) for the SQUASH. The SQUASH has been validated using an accelerometer, the CSA Inc. Activity Monitor (model AM7164-2.2), showing a Spearman correlation coefficient between CSA readings and total activity score of 0.45 (95%-CI 0.17-0.66).[10]

Statistical analysis

The data were analyzed with SPSS 14.0. Descriptive statistics were used to describe the main characteristics. To determine to what extent patient characteristics (independent variables) are predictive for their amount of physical activity (dependent variable), linear regression (backward) analysis was used. Additionally, binary logistic regression modelling (backward) was used to determine the extent to which patient characteristics (independent variables) were predictive in meeting international guidelines (dependent variable) on health-enhancing physical activity. In that respect, the dependent variable (meeting the guidelines) was coded as 0 = not meeting the guidelines and 1 = meeting the guidelines. Patients were considered to meet the guidelines when they spent 30 minutes or more on moderately- and/or vigorously intense physical activity on five, preferably all days of the week.[12] In both regression analyses, effect modification of age, gender, Charnley classification and family status was assessed. P values lower than 0.05 were considered to indicate statistical significance.

RESULTS

Baseline characteristics are shown in Table 1. Mean age was 62.7 years, with 60.8% females. About half (50.9%) had a primary or secondary education.

Table 1: Baseline characteristics of the study population (n=273)

Age (mean ± SD)	62.7 ± 13.7
Gender (male/female)	107 (39.2) / 166 (60.8)
Education	
- Elementary and secondary	139 (50.9)
- Higher	127 (46.5)
- Missing	7 (2.6)
Family status	
- Living alone	76 (27.8)
- Living with partner and/or children	195 (71.4)
- Missing	2 (0.7)
General comorbidity	
- None	92 (33.7)
- 1-2	88 (32.2)
- >2	76 (27.8)
- Missing	17 (6.2)

Values are expressed as number (percentage).

Linear regression analysis was used to determine to what extent aspects of patient characteristics are predictive for level of physical activity (dependent variable). Due to missing data for nine patients, the level of physical activity could not be calculated.

The results from the final model show that age, education and family status significantly predict people's level of physical activity. The R^2 for this model was 0.19, which implies that almost 20% of the variance could be explained. Interaction terms were not significant, indicating no effect modification.

6

Binary logistic regression was used to determine to what extent aspects of patient characteristics are predictive in meeting international guidelines (dependent variable). Due to missing data for eleven patients, compliance with these guidelines could not be calculated.

The results showed that gender significantly predicts compliance with the guidelines (OR = 2.06, 95% CI 1.20-3.54). Both education and family status reached borderline significance, with odds ratios of .62 (95% CI .38-1.04) and .56 (95% CI .31-.99) respectively. This is also reflected in the Hosmer-Lemeshow goodness-of-fit statistic ($\chi 2$ = 4.560; p=0.803), which tests the hypothesis that the observed data are significantly different from the predicted values of the model. A non-significant value for this test indicates that

Table 2: Predictive values of patient characteristics on level of physical activity (N=264)

	B	SE B	β	P
Initial model[a]				
- Constant	2817.59	510.78	-	-
- Age	-28.02	5.92	-.30	.00**
- Gender	-155.09	164.26	-.06	.35
- Education	325.33	154.92	.13	.04*
- Charnley dummy 1	16.03	200.99	.01	.94
- Charnley dummy 2	-425.43	281.75	-.09	.13
- Comorbidity dummy1	8.09	186.39	.00	97
- Comorbidity dummy2	-167.32	192.56	-.06	.39
- Family status	319.10	183.75	.11	.08
Final model[b]				
Constant	2567.90	487.10		
Education	400.21	5.63	-.31	.00**
Age	-30.35	150.36	.15	.01*
Family status	469.92	169.65	.16	.01*

[a] model with all potential predictive variables
[b] model with predictive variables with a significant contribution
*Note R^2=.19. * $p<0.05$; ** $p<0.01$.*

Table 3: Predictive values of patient characteristics for meeting the international guidelines (N=262)

		95% CI for exp b			
	B (SE)	lower	Exp b	upper	p
Initial model[a]					
- Constant	-.25 (.66)	-	.78	-	-
- Age	.01 (.10)	.99	1.01	1.03	.24
- Gender	.69 (.29)	1.13	1.99	3.48	.02*
- Education	-.37 (.27)	.40	.68	1.16	.16
- Charnley dummy 1	-.09 (.35)	.47	.92	1.80	.80
- Charnley dummy 2	-.39 (.49)	.26	.68	1.75	.42
- Comorbidity dummy 1	-.53 (.32)	.32	.59	1.11	.10
- Comorbidity dummy 2	-.18 (.34)	.43	.84	1.61	.59
- Family status	-.42 (31)	.36	.66	1.22	.18
Final model[b]					
- Constant	-.38 (.28)	-	.69	-	-
- Age	.01 (.01)	.99	1.01	1.03	.26
- Gender	.72 (.28)	1.2	2.06	3.54	.01*
- Family status	-.58 (.30)	.31	.56	.99	.05
- Education	-.47 (.63)	.38	.62	1.04	.07

[a] model with all potential predictive variables
[b] model with predictive variables with a (borderline) significant contribution
Note: final model R^2=.046 (Hosmer & Lemeshow),
.061 (Cox & Snell),.082(Nagelkerke).Modelx^2= (1) = 16.62
** $p< 0.05$.*

the model predicts real-world data fairly well. However, the Nagelkerke R^2 for this model was 0.082, which implies that 8.2% of the variance could be explained. In the end, 61.1% of the patients could be classified correctly. Interaction terms were not significant, indicating no effect modification.

DISCUSSION AND CONCLUSION

Discussion

It can be concluded that aspects of patient characteristics are predictive for the level of physical activity of patients after THA.

Results of the linear regression analysis showed that almost 20% of the variance could be explained by education, age and family status. This percentage can be considered modest and in line with percentages found in cross-sectional and longitudinal studies of physical activity behavior. In general percentages vary between 20% and 30%.[13]

Results of the logistic regression showed that 8.2% of the variance could be explained by compliance with the international guidelines. This result can be considered low. The major explanation is probably the fact that recoding the level of physical activity as it is used as the outcome variable in the aforementioned linear regression analysis into a dichotomous outcome variable (meeting international guidelines — yes or no) leads to loss of information, and consequently to a more global indication of physical activity behavior.

The fact that education, age and family status all contribute significantly to the prediction of the level of physical activity of people with a THA is in line with results found in literature with respect to the general population.[7] The fact that joint-specific comorbidity was not predictive for level of physical activity is in line with the assumption that, one year after the operation, patients are able to function again at the same activity level as healthy counterparts. With respect to general comorbidity it can be concluded that this comorbidity was generally mild, not leading to an adverse effect on level of physical activity. In the logistic regression analysis only gender remained a significant predictor of meeting the norm, with men meeting the norm twice as much as women. This result is also in line with results found in literature.[7]

Conclusion

The results of this study show that with simple preoperatively available patient characteristics, patients who are at a potential risk of being insufficiently physically active can be identified.

Practice implications

Until now, orthopedic surgeons and other health care professionals are not focused on the beneficial aspects of physical activity for patients after a THA. Emphasis should be laid on patient education, making patients aware of the beneficial effects of regular physical activity. With simple preoperatively available characteristics, patients at risk can be identified. As patients visit the outpatient clinic on a regular basis postoperatively, this offers the opportunity to educate and stimulate them to become physically active (again).

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CHAPTER 7

Physical activity behavior of patients one year after Primary Total Hip Arthroplasty

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Submitted

ABSTRACT

Despite recognized benefits of regular physical activity for general health and musculoskeletal fitness, little is known about the physical activity behavior of patients after total hip arthroplasty (THA). A multicenter prospective study analyzing physical activity behavior was conducted in 653 patients one year after primary THA (mean age, 70.3 years; mean follow-up, 52.4 weeks) using the SQUASH questionnaire. Subanalyses were performed in different age groups and determinants of physical activity assessed. Additionally, compliance with guidelines of health-enhancing physical activity and determinants of compliance with these guidelines were assessed. Patients were physically active 1468 minutes a week. Most was spent in household and leisure time, while activities were mostly in the light-intensity category. Younger patients were physically more active than older patients ($p = 0.00$). A lower body mass index was also predictive of a higher level of physical activity ($p = 0.00$). Patients complied with the guidelines of health-enhancing physical activity in 67%. The guidelines were met more often by younger patients, males and patients without problems in the lower extremities. Although this percentage is comparable to the general population, large proportions of patients are insufficiently physically active and should be stimulated to become more active.

INTRODUCTION

In Western society, regular physical activity is considered to be one of the most important lifestyle behaviors affecting health. It has been shown to be effective in the primary and secondary prevention of several chronic conditions and is linked to a reduction in all-cause mortality.[1,2] Furthermore, it enhances musculoskeletal fitness, which is positively associated with functional autonomy and negatively associated with the risk of falls in older adults.[3,4] At the same time, a lack of physical activity is considered to be an important burden on public health,[5] contributing together with an unhealthy diet to the epidemic of obesity in society.[6,7] Therefore, international and Dutch guidelines have been developed for levels of health-enhancing physical activity. These guidelines originally recommended 30 minutes or more of moderate-to-intense physical activity on at least 5 days a week.[8,9] These guidelines were recently updated, now recommending 30 minutes or more of moderate-intensity aerobic (endurance) physical activity at least 5 days per week, or vigorous-intensity physical activity for a minimum of 20 minutes at least 3 days per week.[10,11]

Current population surveys provide detailed information on the physical activity behavior of the general population,[6,12] showing that large segments are insufficiently physically active. In 2007, only 39.3% of American adults aged ≥ 65 met the guidelines,[12] while in the Netherlands this percentage was 66% for adults aged ≥ 55.[6] However, so far little is known about the physical activity behavior of a large and growing[13,14] subset of the population: patients after total hip arthroplasty (THA). Literature on the physical activity of patients after THA is sparse and predominantly pertains to sports and walking activities,[15-29] or has used tools like the University of California Los Angeles activity score (UCLA) or Grimby score to categorize level of physical activity.[30-33] Furthermore, the main focus of these studies has lied on the determination of realistic loading conditions for hip prostheses and the implication of certain activities on implant survival, as well as on the return to specific activities after THA, but not on the beneficial effects of regular physical activity. Therefore, in view of the importance of regular physical activity, more insight into the physical activity behavior of patients after THA is needed. In the end, insight into this behavior would also widen the perspective on the survival rates of hip prostheses,[34,35] as physical activity is recognized as one of the most important determinants of prosthetic wear and loosening,[36] and allow for a better comparison between the results of procedures performed using different surgical approaches (e.g. minimally invasive versus traditional) or with different prosthetic designs and/or bearing couples.

For these reasons, we assessed the habitual physical activity behavior of patients after a primary THA. We also analyzed this behavior in different age groups and assessed determinants predictive of the amount of physical activity in patients after THA. Compliance with the guidelines of health-enhancing physical activity and determinants predictive for meeting these guidelines were assessed as well.

MATERIALS AND METHODS

A prospective cohort study was conducted in three orthopedic centers (1 university medical center, 2 regional hospitals). All patients who had undergone an elective primary THA because of primary osteoarthritis of the hip between February 2005 and January 2007 were consecutively included. Patients who had died at the time of follow-up, who had other lower limb arthroplasties performed in the period of follow-up, or who had cognitive limitations were excluded. Patients were sent a self-reported questionnaire with an explanatory letter about one year postoperatively. The minimum duration of follow-up was 37 weeks (mean, 52.4 weeks; range, 37-77 weeks). From the 848 eligible patients, 653 (77%) completed the questionnaire and were included. There were 484 female patients (74.1%). Mean age at surgery was 70.3 years (range 44-92 years) (Table 1). Mean body mass index (BMI) of the patients was 27.0 kg/m^2 (SD 4.1). Most of the patients lived together with a partner (59.1%) and had a lower educational level (49.3%) (Table 1). A total of 181 patients (27.7%) reported no additional comorbidity, 263 patients (40.3%) 1-2 comorbidities and 209 patients (32.0%) more than 2 comorbidities. Complications occurred in 47 (7.2%) patients. There were 8 (1.2%) dislocations, 3 (0.5%) sciatic nerve palsies, 3 (0.5%) superior gluteal nerve palsies, 2 (0.3%) periprosthetic fractures and 2 (0.3%) malpositioned prostheses necessitating revision surgery. At follow-up 271 patients (41.5%) reported some complaints in the lower extremity.

Subanalyses were performed for patients in three age groups (< 55, 55-75, and > 75). Main characteristics of patients in these groups are shown in Table 1. Comparison of characteristics between groups showed more patients living alone ($p = 0.00$) and with a lower educational level ($p = 0.00$) among the older patients, and a higher BMI among the younger patients ($p = 0.00$) (Table 1).

The study was conducted in accordance with the regulations of the medical ethical boards of the participating hospitals. Patients were informed in the explanatory letter that return of the completed questionnaire would be taken as consent to participate.

Surgeries were performed by 15 staff surgeons, or under direct supervision of one of these surgeons. Patients were operated using a posterolateral or anterolateral approach. This approach was surgeon-specific, with each surgeon consistently using the same approach for all THAs performed during the study period. Different types of implants and fixation types were used. Patients were allowed full weight-bearing the second day after surgery, using crutches during the first three postoperative months.

The questionnaire sent to patients contained questions about demographic

Table 1. Main characteristics of patients after primary THA (total group and different age groups)

	Primary THA *n* = 653	Patients < 55 y. *n* = 18	Patients 55-75 y. *n* = 455	Patients >75 y. *n* = 180	p-Value
Age (years) (mean (range))	70.3 (44-92)	51.0 (44-54)	67.2 (55-75)	80.0 (76-92)	0.00
Sex, male/female (n (%))	169(25.9)/484 (74.1)	8 (44.4)/10 (55.6)	119 (26.2)/336 (73.8)	41 (22.8)/139 (77.2)	0.13
Body Mass Index (kg/m²) (mean ± SD)	27.0 ± 4.1	28.1 ± 5.7	27.3 ± 4.1	26.1 ± 3.9	0.00
Family status (n (%))					0.00
Alone	223 (34.2)	1 (5.6)	118 (25.9)	104 (57.8)	
With partner	386 (59.1)	7 (38.9)	310 (68.1)	69 (38.3)	
With partner and children	28 (4.3)	10 (55.6)	17 (3.7)	1 (0.6)	
With children	7 (1.1)	-	5 (1.1)	2 (1.1)	
Unknown	9 (1.4)	-	5 (1.1)	4 (2.2)	
Educational Level (n (%))					0.00
Lower	322 (49.3)	3 (16.7)	219 (48.2)	100 (55.6)	
Secondary	201 (30.8)	6 (33.3)	144 (31.7)	51 (28.3)	
Higher	65 (9.9)	4 (22.3)	48 (10.6)	13 (7.3)	
Other	15 (2.3)	1 (5.6)	9 (2.0)	5 (2.8)	
Unknown	50 (7.7)	4 (22.2)	35 (7.7)	11 (6.1)	
Comorbidity (n (%))					0.53
None	181 (27.7)	6 (33.3)	128 (28.1)	47 (26.1)	
1-2	263 (40.3)	8 (44.4)	187 (41.1)	68 (37.8)	
>2	209 (32.0)	4 (22.2)	140 (30.8)	65 (36.1)	
Complications (n (%))	47 (7.2)	2 (11.1)	27 (5.9)	18 (10)	0.16
Complaints, lower extremities (n (%))	271 (41.5)	10 (55.6)	176 (38.7)	85 (47.2)	0.09

Kruskal-Wallis test was used to compare family status, educational level and comorbidity; ANOVA to compare age and BMI; Chi-square to compare sex, complications and complaints of the lower extremities between patients in different age groups.

characteristics and the presence of additional comorbidities and/or complaints in the lower extremities. It also contained a physical activity questionnaire, the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH).[37] The SQUASH contains questions on activities at work or school, commuting activities, household activities and leisure-time activities, thus measuring habitual physical activity level. It is structured in such a way that it allows assessment of compliance with the international and Dutch physical activity guidelines, and is used by the Dutch government to monitor the physical activity behavior of the general Dutch population. It asks to recall physical activity during an average week in the past months and consists of three main queries: days per week, average time per day and intensity (effort). Using the Ainsworth compendium of physical activities[38] a subdivision of activities is made into three intensity categories, light, moderate and vigorous, based on METabole equivalents (MET). One MET is defined as the energy expenditure for sitting quietly. METs higher than 1 are activities defined as multiples of the resting metabolic rate. Cutoff points for intensity categories are based on the Dutch physical activity guideline,[8] which is derived from international physical activity guidelines.[9] For adults (ages 18-54), activities with a MET value of 2 to 4 are classified as light, 4 to 6.5 as moderate, and ≥ 6.5 as vigorous intensity. For older adults (age ≥ 55) activities of 2 to 3 METs are classified as light, of 3 to 5 METs as moderate, and ≥ 5 METs as vigorous intensity. Activities with a MET value lower than 2 are not included because they are considered to contribute negligibly to the habitual activity level. Patients were considered to be meeting the guidelines if they spent 30 minutes or more on moderately intense or vigorously intense physical activity at least 5 days a week, as this study was conducted before the issuing of the updated 2007 guidelines. The SQUASH has been validated using an accelerometer as criterion measure in a general adult population[37] and in an older adult population after primary THA.[39] Age, sex, details about the operation and postoperative complications were extracted from the medical records.

Statistical analyses were performed using the SPSS 12 software (SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606). Descriptive statistics were used to describe the main characteristics of the patients. ANOVA was used to compare continuous variables. To test for differences in activities of daily living and intensity of those activities between patients in the different age groups a Kruskal-Wallis test was used. When establishing a difference, the age groups were also compared to each other using the Mann-Whitney U-test. To determine whether aspects of patient characteristics (age, sex, BMI, family status, education, complaints in the lower extremities and comorbidity, included as dummy variables) and the occurrence of complications or hospital of surgery (independent variables) were predictive for the amount of physical activity (dependent variable), linear regression (backward selection) was used. Differences in meeting the guidelines between age groups were assessed by means of a Kruskal-Wallis test and additional Mann-Whitney U-test when differences were found. Binary logistic regression modeling (backward selection) was used to determine whether patient characteristics, the occurrence of complications or hospital of surgery (independent variables) were predictive in meeting the guidelines (dependent variable). In that respect, the dependent variable (meeting the guidelines) was coded as 0 = not meeting the guidelines and 1 = meeting the guidelines. A p-value < 0.05 was considered statistically significant. In case of multiple-level testing the significance level of the test was corrected according to the Bonferroni adjustment from 0.05 to 0.017.

RESULTS

Patients spent a mean amount of 1468.1 minutes (SD, 1138.3 minutes (min.)/w.) on physical activity during the week (Table 2). Most of the time was spent on household (mean, 756.3 min./w.; SD, 766.5 min./w.) and leisure-time activities (mean, 584.5 min./w.; SD, 657.8 min./w.). With respect to intensity of the activities most of the time was spent on light-intensity physical activities (mean, 805.1 min./w.; SD, 800.4 min./w.).

Table 2. Overview of physical activities in daily life of patients after primary THA (total group and different age groups)

	Total group N = 653	*Patients < 55 y. n = 18*	*Patients 55-75 y. n = 455*	*Patients >75 y. n = 180*	*p-Value*
Activities at work	*99.0 (404.6)*	*1093.3 (1047.7)*	*97.14 (388.2)*	*4.3 (35.9)*	*0.00[a,b]*
Activities to/from work	*28.3 (183.1)*	*25.6 (44.5)*	*34.3 (204.3)*	*13.5 (125.3)*	*0.00[a,b,c]*
Household activities	*756.3 (766.5)*	*634.2 (628.4)*	*809.3 (792.2)*	*634.8 (698.1)*	*0.02[c]*
Leisure-time activities	*584.5 (657.8)*	*826.4 (1407.2)*	*654.3 (670.3)*	*384.2 (436.0)*	*0.00[c]*
Sports activities	*68.3 (185.0)*	*58.3 (72.4)*	*82.5 (210.9)*	*33.6 (98.8)*	*0.00[c]*
Bicycling	*164.9 (283.7)*	*127.2 (133.8)*	*194.5 (308.3)*	*93.8 (207.4)*	*0.00[b,c]*
Walking	*175.2 (241.2)*	*210.8 (584.0)*	*179.7 (233.9)*	*160.1 (200.9)*	*0.29*
Light intensity	*805.1 (800.4)*	*1423.3 (1214.7)*	*853.2 (810.2)*	*622.1 (671.1)*	*0.00[b,c]*
Moderate intensity	*333.6 (508.0)*	*846.4 (1316.2)*	*361.5 (504.9)*	*211.8 (292.0)*	*0.00[b,c]*
Vigorous intensity	*329.4 (458.5)*	*309.7 (601.0)*	*380.3 (470.8)*	*202.8 (382.9)*	*0.00[c]*
Total	*1468.1 (1138.3)*	*2579.4 (2020.3)*	*1595.0 (1116.7)*	*1036.8 (903.7)*	*0.00[b,c]*

Values are expressed as mean minutes per week (SD).
p value : comparison between patients in the three different age groups (Kruskal-Wallis test).
[a] p < 0.016 when comparing patients < 55 y.. to patients 55-75 y.. (Mann-Whitney test).
[b] p < 0.016 when comparing patients < 55 y.. to patients > 75 y.. (Mann-Whitney test).
[c] p < 0.016 when comparing patients 55-75 y. to patients > 75 y. (Mann-Whitney test).

Subanalyses for patients in the different age groups (< 55, 55-75, > 75) showed that younger patients were physically more active than older patients (p = 0.00) (Table 2). The participation of patients aged < 55 in activities at work contributed for a large part to this higher activity level. Comparison of patients in the 55-75 age group to those aged < 55 showed that these patients were less active in activities at work (p = 0.00) and in activities to/from work (p= 0.00). Patients aged < 75 were less active in total amount of physical activity (p = 0.00) compared to those aged < 55. They spent less time doing activities at work (p = 0.00), activities to/from work (p = 0.00), and bicycling (p = 0.00). Furthermore, they spent less time in light- (p = 0.00) and moderate- (p = 0.00) intensity physical activity. Compared to patients aged 55-75, patients > 75 were less active with respect to total amount of physical activity (p = 0.00), activities to/from work (p = 0.00), household activities (p = 0.00) and overall leisure-time activities (p = 0.00), as well as sports activities (p = 0.00) and bicycling (p = 0.00). They were also less active in the different intensity categories of physical activity (p = 0.00).

The results from the linear regression model showed that age at the time of the operation (p = 0.00) and BMI (p = 0.00) significantly predicted patients' level of physical activity, with younger patients and patients with a lower BMI showing higher activity levels. The R^2 for this model was 0.15, which implies that 15% of the variance could be explained.

Patients complied with the recommendations of health-enhancing physical activity in 67% of cases. This percentage was 52.3% for patients aged < 55, 71.8% for patients aged 55-75 and 55.1% for patients aged > 75.

Binary logistic regression analysis showed that age (odds ratio = 0.95, 95% CI 0.93-0.97; p =0.00), gender (men coded as 0, female coded as 1) (odds ratio = 0.62, 95% CI 0.40-0.94; p=0.03) and the presence of complaints in the lower extremities (no complaints coded as 0, complaints coded as 1) (odds ratio = 0.58, 95% CI 0.41-0.81; p=0.00) significantly predicted compliance with the guidelines. Younger patients, male patients and patients without complaints in the lower extremities met the guidelines more often. The validity of the model is reflected in the Hosmer-Lemeshow goodness of fit statistic (χ^2 = 8.631; p = 0.37), which tests the hypothesis that the observed data are significantly different than the predicted values from the model. A non-significant value for this test indicates that the model predicts real-world data fairly well.[40] The Nagelkerke R^2 for the model was 0.095, which implies that 9.5% of the variance could be explained. In the end, 68.6% of the patients could be classified correctly.

DISCUSSION

Despite the beneficial effects of physical activity on general health and musculoskeletal fitness, and the recognition of its potential role as a negative determinant of prosthetic wear, little is known about the habitual physical activity behavior of patients after primary THA. To our knowledge, this is the first prospective multicenter study to conduct an in-depth analysis of habitual physical activity behavior, giving a first impression of the habitual physical activity behavior of patients one year after primary THA.

Our study may be subject to some limitations. The first is related to the fact that we did not perform a non-response analysis, hence there might be a selection bias. However, our study is characterized by a high response rate (77%) and a large sample-size (n = 653). Secondly, we used a self-administered recall questionnaire to assess level of physical activity. Although self-report instruments continue to be the most widely used type of physical activity measure, allowing collection of data from a large number of people at low costs, there are limitations to their use. Recalling physical activity is a highly complex cognitive task and instruments can vary in their cognitive demands. Particularly older adults may have memory and recall skill limitations.[41] However, the SQUASH has been validated in a population of adults[37] as well in a population of older adults after primary THA,[39] showing actually identical measurement properties. These measurement properties of the SQUASH are also comparable to those of other physical activity questionnaires.[41,42] A final limitation of self-reported questionnaires is that people tend to overestimate their physical activity level.[41]

Comparison of the results of our study with those of previous studies is troubled by the fact that, so far, level of physical activity has been determined predominantly by means of categorical scoring tools such as the UCLA activity score[30] and the Grimby scale.[33] These scoring tools categorize activity level of patients, but fail to provide detailed information on duration, frequency and energy expenditure of activities performed by patients. Furthermore, these scoring tools have not been validated. Results of studies using the UCLA score indicate a moderate activity level in THA patients at least 3 years postoperatively.[25,31,32] Using the Grimby scale, a light-to-moderate-intensity activity level was found in THA patients 1 to 2 years postoperatively.[15] In interpreting these results it should be noted that these studies not only differ from our study with respect to the scoring tool used, but also with respect to the populations in which physical activity was measured as well as time of follow-up.

We are only able to compare the volume of physical activity found in this prospective study to the results of an earlier, retrospective study at our department.[43] This cross-sectional study addressed habitual physical activity in a cohort of patients who had a primary THA because of a primary or secondary osteoarthritis of the hip. After a mean follow-up of 39 months (range 17-78 months) we found a mean amount of physical activity of 1601.0 minutes per week in a population of 273 patients (mean age, 62.7 years; SD, 13.7 years). This total amount of physical activity is slightly higher than in the prospective, multicenter study of 653 patients, perhaps because the mean age of the patients was lower than in this current study. It might also reflect a slight further increase of physical activity in the years after the operation. Just like in this study, most of the time was spent on household activities (mean, 642.6 min./w.) and leisure-time activities (mean, 550.8 min./w.), and mostly light-intensity activities were performed (mean, 1003 min./w.).

When comparing physical activity of patients in different age groups, total volume of physical activity appeared to be higher in younger patients. Participation in work activities accounted largely for the higher activity level found in patients aged < 55 compared to older patients. This finding supports the presumption of higher activity levels in younger patients as a possible explanation of the observed lower prosthetic survival rates among younger patients.[44]

Assessment of the determinants of physical activity also showed the influence of age and BMI. Surprisingly, presence of comorbidity or occurrence of complications after the operation was not predictive of physical activity level.

Among the general Dutch population, 54 % of people aged 25-45, 63% of people aged 45-65, and 58% aged over 65 complied with the guidelines of health-enhancing physical activity in 2007.[6] These percentages appear to be in line with our results, showing percentages of compliance of 52.3% in patients aged < 55, 71.8% in patients aged 55-75, and 55.1% in patients aged > 75. The higher-intensity level of physical activity needed to comply with the guidelines of health-enhancing physical activity among younger patients is responsible for the lower percentage of compliance with the guidelines in the youngest patient group, even though the absolute amount of physical activity is higher among these patients compared to older patients. Younger patients, males, and patients without problems in the lower extremities complied more often with the guidelines.

In conclusion, this study has given a first impression of the physical activity performed by patients after primary THA one year after the operation. It has shown that younger patients are physically more active than older patients. Besides age, BMI was found to be an important determinant of physical activity behavior. Furthermore it has shown that the extent to which patients comply with guidelines of health-enhancing physical activity varies with age and gender, while the percentages found appear to be in line with those of the general population. Although this finding can be considered to be a successful outcome after THA, it also means that large proportions of patients one year after primary THA are insufficiently physically active. Given the beneficial effects of regular physical activity, these patients should be stimulated to become physically more active.

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CHAPTER 8

General discussion

INTRODUCTION

This thesis has provided a first detailed insight into the habitual physical activity behavior of patients after total hip arthroplasty (THA), showing the volume of time spent by patients in the different domains of habitual physical activity as well as in different intensity categories of physical activity. For the first time, compliance with guidelines for health-enhancing physical activity of patients after THA was assessed.

In assessing this habitual physical activity behavior the main focus lie on the beneficial effects of regular physical activity on general health and musculoskeletal fitness — something new in orthopedics. So far, physical activity had only been considered as a potential negative determinant of prosthetic wear and loosening, affecting the longevity of the implanted hip prosthesis. This new perspective on physical activity is in line with an increasing attention on the benefits of regular physical activity as well as the risks of sedentary behavior, which are common in today's society.[1-3]

In this general discussion two main topics within this thesis will be discussed in more detail. First of all, from a methodological point of view, the assessment of physical activity within an orthopedic context will be examined. Pros and cons of self-reported questionnaires, such as the Short Questionnaire to Assess Health-enhancing physical activity (SQUASH),[4] will be discussed in detail. The role of body-fixed sensor-based technology, such as accelerometers, as a promising method of assessing physical activity behavior in an objective way within orthopedics is also discussed. Second, the promotion of physical activity within an orthopedic perspective is addressed. This discussion will end with suggestions for future research.

Assessment of physical activity within an orthopedic context

Status quo

In order to gain more insight into the habitual physical activity behavior of patients after THA, an appropriate assessment tool has to be chosen. So far, outcome assessment after THA has used mainly physician-based and self-reported disease-specific and generic outcome measures, such as the Harris Hip Score (HHS),[5] the Western Ontario and McMaster universities osteoarthritis index (WOMAC)[6] and the MOS 36-Item Short Form Health Survey (SF-36).[7] However, in Chapter 3 it was shown that an outcome measure like the WOMAC is clinically not useful to predict the physical activity behavior of patients after THA. This result is in line with a study into the predictive power of the HHS on activity level.[8] It probably reflects the fact that, with respect to physical functioning, these outcome measures only assess functional limitations, while physical activity is determined by many other factors which include demographic, social, psychological and environmental dynamics.[9] It can be concluded that functional limitations and physical activity are different aspects of physical functioning. This finding can probably be generalized to other disease-specific and generic outcome measures.

Nowadays the UCLA activity score[10] is often used in orthopedics to categorize patients according to their physical activity level. A major limitation is that it fails to provide detailed information on the habitual physical activity behavior of patients after THA. Furthermore, it does not allow assessment of compliance with the recommendations for health-enhancing physical activity. Hence a more adequate tool to assess physical activity behavior after THA is needed.

The SQUASH questionnaire

In this thesis the SQUASH[4] was chosen as primary assessment tool, as this questionnaire is also used by Dutch government agencies to monitor the habitual physical activity behavior of the general population; this allowed comparison of the physical activity behavior of patients after THA with the general Dutch population. Self-reported questionnaires, such as the SQUASH, allow collection of data from different domains of physical activity from a large number of people at a low cost and with minimal burden to people.[11] However, the SQUASH had so far only been validated in a population of healthy adults. For that reason, we first assessed the measurement properties of the SQUASH in a population of older patients after THA (Chapter 4). This revealed that the SQUASH had acceptable measurement properties for the assessment of physical activity in these patients, comparable to those of the SQUASH in an adult population and to other physical activity questionnaires. Still, it also showed that the measurement properties of the SQUASH, just as those of other physical activity questionnaires, are not yet optimal. This may be caused by several factors. Recalling physical activity is a highly complex cognitive task. Although questionnaires vary in their cognitive demands, people — and older adults in particular — may have memory and recall skill limitations.[12] Furthermore, social desirability may lead to an over-reporting of physical activity.[12,13] Finally, the questionnaire may not assess the primary modes of activity of the population under study. Although the SQUASH is short and easy to fill in, it may be affected by some of these limitations. Since it asks patients to recall physical activity during an average week in the past months, it puts a demand on the memory and recall skills of patients. Nevertheless, the measurement properties of the SQUASH in a population of older adults after THA were found to be actually identical to those in a population of adults. Age of the patients therefore seems not to influence the measurement properties of the SQUASH. When considering the domains of physical activity assessed by the SQUASH (commuting activities, leisure-time activities, household activities and activities at work and school), these activities seem to cover most of what is performed by patients after THA. However, questions on commuting activities to/from school are generally not appropriate for patients after THA, while commuting activities to/

from work will only apply to a part of these patients, since many of them will be retired. Consideration could therefore be given to supplementing this question with commuting e.g. to/from volunteer activities, as some retired people and people not employed in occupational settings are involved in such activities.

Some specific remarks have to be made with respect to the SQUASH. In order to assess the energy expenditure of physical activities reported by patients, the SQUASH uses the Ainsworth compendium of physical activities published in 1993.[14] However, in 2000 this compendium was updated by including volunteer and religious activities,[15] extending the number of specific activities and providing updated MET intensity levels for selected activities. This update has not yet been incorporated into the SQUASH. Furthermore, the recommendations for health-enhancing physical activity for adults and older adults were recently updated.[16,17] Although these 2007 updates remain essentially unchanged from the 1995 and 1998 recommendations,[18,19] they clarify several issues which were implicitly formulated in the previous recommendations. For example, they now explicitly incorporate vigorous-intensity physical activity and muscle-strengthening activities, as well as flexibility and balance exercises for older adults, as an integral part of the physical activity recommendation. As the Dutch criteria for compliance with the health-enhancing physical activity recommendations,[20] which are also used in the SQUASH, are based on the 1995 and 1998 recommendations, they should be adjusted to the recent updates.

Finally, the SQUASH has been developed and is used so far only in the Netherlands. It might be of interest to compare the physical activity behavior of patients after THA between different countries. In order to do so, the cross-national reliability and validity of the SQUASH have to be assessed first.

Body-fixed sensor-based technology

Although self-reported physical activity questionnaires are the most frequently employed assessment tool at a population level, novel body-fixed sensor-based technology, such as accelerometers, can provide an objective insight into habitual physical activity of patients after THA. Particularly the availability of powerful micro-controllers, miniature sensors, high-capacity memory and small batteries has allowed the development of ambulatory monitoring systems which minimally interfere with habitual activity and allow the collection of data over longer time periods in a natural environment.[21] With regard to activity assessment in THA, these methods for ambulatory monitoring are particularly relevant to estimate energy expenditure of physical activity, to objectively assess daily physical activity patterns (sitting, standing, walking, etc.), and to estimate joint loading occurring during physical activity. These systems may also play a role in motivating patients to adhere to physical activity intervention strategies by providing objective feedback about their physical activity behavior. They can also be used to tailor the intervention to the needs of the patient.

To assess volume and intensity of physical activity, as well as to estimate activity-related energy expenditure, accelerometers can be used. Accelerometers are mostly worn on the waist and measure and record time-varying accelerations of the body. The summation of accelerations measured during a user-specified time interval (epoch) are collected and reported in "counts". These counts represent the intensity of activity in that epoch. In this way frequency, duration, total volume and intensity of physical activity can be assessed. Furthermore, new generations of accelerometers use sophisticated data-processing approaches, allowing pattern recognition of physical activity.[22] This not only allows for detailed profiling of physical activity, but also of inactivity.[22] In this way a more comprehensive exploration of the links between health and frequency, intensity and duration of physical activity will become possible.[22] Although accelerometer-based physical activity monitoring has evolved, several important limitations still remain. In order to estimate energy expenditure associated with the physical activity performed, a transformation of activity counts into energy expenditure has to be made using some form of regression equation. However, several equations exist and the issue is further complicated by the existence of different cut-point ranges to define the different intensity categories of physical activity (low, moderate, vigorous).[23-25] This will result in markedly different interpretations of the same data.[26] Furthermore, the increased energy expenditure due to increased resistance to body movement (e.g. walking up hills or stairs, carrying loads) or activities involving the extremities (e.g. cycling) is not well accounted for.[27] Approaches to overcome these limitations have included the use of multiple accelerometers, worn on different parts of the body, and a combination of accelerometers with physiological measures such as heart rate monitors.[28]

Body-fixed sensors can also be used to monitor human functioning.[21] Configurations of different body-fixed sensors, such as combinations of accelerometers with gyroscopes (measuring angular velocities), allow the objective assessment of daily physical activity patterns such as sitting, standing and walking. In this way the technology can provide objective data of actual movement behavior. This information can be used to timely recognize deteriorations in motor functioning, which occur during ageing, and can help to opportunely initiate interventions to prevent loss of functional abilities. This objective assessment of physical functioning can also be used to evaluate the result of orthopedic procedures, such as THA.[8]

Another mode of use and interesting possibility of accelerometers from an orthopedic perspective is to use them to calculate hip contact forces occurring during physical activity in daily life. In this thesis the intensity of physical activity has been expressed in metabolic equivalents (METs), because of the thesis' main focus on the beneficial effects of regular physical activity on health and musculoskeletal fitness. Patients were categorized according to their physical activity using these MET values. Although it may be argued that people with higher activity levels, as categorized in this way, will apply more loads and loading cycles to their hip prosthesis, an equivalent level of physical activity can be reached by performing different activities, e.g. running versus swimming. These different activities will result in different hip contact forces, and therefore may have different effects on prosthetic wear and loosening. For that reason, another approach would be to determine the hip contact forces associated with a range of activities in daily life, so that an objective categorization of activities in terms of loading of the hip prosthesis can occur.

At present, hip contact forces have been determined by two distinct methods: direct measurement by means of instrumented hip prosthesis or by mathematical predictions using musculoskeletal modeling techniques.[29] Although the direct measurements provide the most accurate data, this method is costly and technically complex, and so far information from only a few implantations is available.[30-35] For that reason, musculoskeletal models are more commonly employed to estimate hip contact forces.[29] A commonly used computational procedure to analyze forces and moments underlying human movements is inverse dynamics. Based on inverse dynamics one can calculate joint moments and forces based upon a kinematic description of the movement, measurement of the external forces involved and a biomechanical (musculoskeletal) model of the moving system.[36] Position data are typically obtained by a motion analysis system, while ground reaction force data are obtained with a force plate. However, this approach does not allow for collection of data in a natural environment, during activities of daily life — data can only be obtained under laboratory conditions, requiring extensive equipment and expertise. A method has been alternatively developed using accelerometers,[37,38] eventually combined with gyroscopes,[36] to calculate joint forces and moments. In this way accelerometers can also be used to further explore the connection between physical activity and prosthetic wear and loosening.

Finally, body-fixed sensor-based technology could play an important role not only in monitoring the effectiveness of physical activity promotion strategies, but might also be an essential part of such a strategy. Data obtained by the body-fixed sensors could be downloaded by patients to a computer in their home environment or during their visit to the outpatient clinic, and be used to provide objective feedback to patients about their physical activity. It can help motivate them as well as tailor the intervention to their individual needs.[23]

Promotion of physical activity

Status quo

So far no specific physical activity intervention strategy has targeted patients after THA.

However, the effectiveness of intervention strategies to promote physical activity in the general population has been assessed in numerous studies. In a Cochrane review of studies into the effectiveness of such interventions in adults aged ≥16 not living in an institution, it was found that physical activity interventions have a positive and moderate effect on increasing self-reported physical activity and measured cardiorespiratory fitness.[39] There was significant heterogeneity in the reported effects as well as in characteristics of the interventions though. Despite this heterogeneity there was an indication that a mixture of professional guidance and self-direction plus ongoing professional support lead to more consistent effect estimates. The long-term effectiveness of interventions could not be determined, since the majority of studies stopped after 12 months.

The effectiveness of physical activity interventions for older adults (average sample population age ≥50 years; minimum age 40 years) has been evaluated in a review by van der Bij et al.[40] Three types of physical activity interventions were identified. The first type consisted of home-based physical activity interventions, in which an explicit exercise prescription was given and participants had to exercise at home according to it. In the second, group-based physical activity interventions, participants engaged in a supervised group-based exercise program, and in the third, educational physical activity interventions, information was given on exercise and health and participants were encouraged to engage in regular physical activity. The review showed that high participation rates were achieved with short-term physical activity interventions (<1 year). Participation rates declined the longer the intervention duration, although higher participation rates were maintained in the long term in group-based interventions compared to home-based interventions. Participation in educational interventions was generally much lower, with only a minority of participants attending all planned counseling sessions. Changes in physical activity levels were evaluated in only a minority of studies. It appeared that group-based and educational interventions were effective in increasing physical activity in the short-term. Long-term educational interventions were ineffective, while insufficient data were available to assess the long-term effectiveness of group-based interventions. Age was found to influence participation, with higher participation rates among people aged ≥60. It was found that even the very old (≥80) can be motivated to increase physical activity. Gender did not influence participation, although more women tended to participate in physical activity interventions than men. Factors like frequency, type and intensity of the physical activity did not influence participation.

Examples of physical activity intervention strategies which have been applied and evaluated in the Netherlands, and can also be of interest within an orthopedic context, are the Physician-based Assessment and Counseling for Exercise (PACE) intervention strategy[41,42] and the Groningen Active Living model (GALM).[43]

Physician-based Assessment and Counseling for Exercise (PACE)

PACE can be considered as an example of an educational physical activity intervention strategy that targets stimulation of moderate-intensity physical activity in the home situation. This strategy was developed in the United States and uses the transtheoretical model[44] and the social cognitive theory[45] as theoretical framework. It aims to enhance moderate-intensity physical activity through advice from primary care physicians. A randomized controlled trial of a Dutch population of patients aged 18-70 at high risk for developing cardiovascular disease showed that the implementation of the PACE program in general practice was both feasible and acceptable.[42] The program resulted in positive changes in some of the psychosocial determinants of physical activity (perceived barriers, self-efficacy and processes of change) in both the short (8 weeks) and medium terms (6 months). It showed no positive intervention effect on changes in stage of change, level of physical activity or body composition, although there was a trend toward increased physical activity in the entire study group. This result is in line with a previous study into the effectiveness of the PACE conducted in the Pacific Northwest,[46] which showed that a one-time PACE counseling session with minimal reinforcement, in a setting with high baseline levels of activity, was not effective in furthering physical activity. This does however contrast with the results of a study into the short-term effectiveness of the PACE in a population of sedentary US patients over age 18. In this study, physician-based counseling for physical activity was found to be efficacious in producing increases in moderate physical activity among previously sedentary patients. In general, evidence with respect to the effectiveness of primary care physician-based counseling on physical activity has been found to be inconclusive,[47-49] necessitating further research.

Groningen Active Living model (GALM)

GALM can be considered as an example of a group-based physical activity intervention. It was designed to stimulate leisure-time physical activity in sedentary and underactive older adults aged 55-65. GALM is based on a process model of behavioral change in which behavioral change is seen as a multidimensional and dynamic process. The strategy is thus built primarily on insights of social cognitive theory, and for structuring of the dynamics of the behavioral change process on the stages of change model.[43] The 55-65 age group was chosen because of its high prevalence of insufficient physical activity and the fact that it could benefit from regular increases in physical activity for many years to come. GALM consists of a leisure-time physical activity program, emphasizing moderate-intensity recreational sports activities, which is provided to participants in fifteen 60-minute sessions at a frequency of once a week. The physical activities are tailored to participants by type, format, intensity and frequency. The effects of the GALM on energy expenditure, health and fitness outcomes have been evaluated after 6 months[50] and after 12 months,[51] and compared to a matched control group of people who were put on a waiting list for participation in the GALM program. The 6-month results showed significant effects on energy expenditure for physical activity as well as on health and fitness indicators. However, similar positive effects were found in the control group. Evaluation after 12 months showed that participation in the GALM program had improved energy expenditure in recreational sports activities, which was also reflected in increases in performance-based fitness. The increase in energy expenditure in leisure-time activities seemed to be only a short-term effect though (6 months), and no improvements in other health indicators were found.

Promotion of physical activity within an orthopedic context

The foregoing description of studies into the effectiveness of physical activity intervention strategies has shown that at present it is not possible to identify one single successful physical activity intervention strategy which could be directly applied to patients after THA. Hence no preference can be given to any one particular type of intervention strategy. Intervention strategies appear to be effective, at least in the short term, toward increasing activity level of participants. Long-term participation may be a bigger challenge. An approach in which physical activity is integrated into the routine of daily life might help overcome this problem, but alternatively the dynamics of a group process could also be used by applying a group-based intervention strategy.

Several studies have identified the important role of professional support and guidance for the effectiveness of a physical activity intervention strategy.[39,52,53] This fact can serve as an excellent starting point to develop a physical activity intervention strategy for patients after THA, as the postoperative period offers an excellent opportunity to provide this professional support and guidance. This period is characterized by frequent contact with the orthopedic surgeon, the general practitioner and the physical therapist, and in this way offers unique opportunities to create awareness among patients of the beneficial effects of health-enhancing physical activity, to stimulate them to become physically (more) active, to tailor the intervention to the patient, and finally to monitor the effects of the intervention.

As part of the postoperative rehabilitation, patients after THA will be exercising under the supervision of a physical therapist to regain their functional abilities. These regular contacts could also be used to counsel patients about the beneficial effects of regular physical activity, advice and instruct patients about appropriate physical activities with regard to the implanted hip prosthesis, and initiate a physical activity intervention strategy. Very importantly, these efforts should be enforced by the orthopedic surgeon, who may act as a very powerful motivational figure and source of advice and support.[52,53] If other important comorbidities are identified, which might affect the ability to become physically active, there should be counseling from other health-care professionals. In this way, the intervention strategy can be tailored to the functional capabilities of the patient, and therapeutic as well as preventive physical activity can be integrated. This integration is in line with the recent 2007 ACSM/AHA recommendations for older adults.[19] The ACSM/AHA propose that every older adult should have an activity plan to achieve the recommended levels of physical activity. Subsequently, patients should be offered a specific home-based, educational or group-based physical activity intervention program. The regular contacts at the outpatient clinic in the first year after the operation, as well as contact with the general practitioner should be used to reinforce as well as monitor the physical activity intervention strategy. Counseling of patients during the visits at the outpatient clinic can take place on an individual basis, but can also be group-based, in line with current developments in which postoperative follow-up is conducted in a group setting. Since this scenario illustrates that such a physical activity intervention strategy necessitates a multidisciplinary involvement of health-care professionals, strong consideration should be given to the appointment of a "health counselor" who acts as central initiator and coordinator of the intervention strategy. Given the frequent visits of the patient to the outpatient clinic of the hospital in the first year after the operation, and subsequently —albeit less frequently — in the years after, it seems logical to position this health counselor in the setting of the hospital. However, the health counselor should also have close and regular contact with general practitioners and physical therapists outside the hospital to support them in counseling patients on physical activity. In this way, every contact of the patient with one of these health-care professional can be used towards physical activity counseling.

When initiating a physical activity intervention strategy one should be aware of the potential barriers to counseling by health-care professionals.[54] One of these barriers is the fact that until now exercise and promotion of health-enhancing physical activity have not been seen as a priority by most health-care professionals, including those involved in the care of patients after THA. By contrast, patients are frequently advised not to be too active so as not to compromise the survival of their hip prosthesis. Although this certainly deserves strong consideration, many health-enhancing physical activities can probably be performed without any negative effects to the hip prosthesis. From this perspective, patients after THA should receive clear instructions regarding the activities they can perform safely without jeopardizing their prostheses. However, consensus guidelines for safe and appropriate activities for patients after THA are so far lacking in the Netherlands. Furthermore, counseling patients on physical activity will take a considerable amount of time and generally will not fit in the time constraints of a regular office visit — although in the PACE strategy, with the help of effective techniques, counseling was achieved in 2 to 5 minutes. A health-counselor can help overcome some of these barriers.

In the end, all these efforts will only be attractive and affordable to health-care professionals if they are accompanied by financial incentives for this health counseling. For this reason, politics and insurance companies can play an important supportive and catalyzing role in the development and implementation of such an intervention strategy. Recent examples of developments in this direction are initiatives like *bewegen op recept* (movement by prescription)[55] and the *beweegkuur* (treatment by movement)[56]. In the initiative *bewegen op recept* inactive patients are referred to a physical activity intervention strategy by their general practitioner. The *beweegkuur* aims to increase physical activity in patients with or at risk of type-2 diabetes mellitus. Research is currently planned to analyze the effectiveness of the *beweegkuur*. If this strategy is proven to be effective it will be incorporated into the health insurance of people in the Netherlands, and will be extended to other chronic conditions.[2] Considerations to include preventive measures, such as membership of a gym, into the health-insurance of patients may be other steps in this direction.

Finally, initiatives to increase the physical activity level of patients after THA and of orthopedic patients in general would be greatly facilitated if the orthopedic community would also pick up this big challenge facing modern Western society to stimulate people to become more physically active. Although this needs a more holistic view on patient care than we, orthopedic surgeons, are generally used to, such a view would fit excellently into the credo of the Dutch orthopedic society *zorg voor beweging* (ensure movement).

Future research

This thesis has provided a clear initial insight into the habitual physical activity behavior of patients after THA, but the results cannot be generalized, as the study population consisted of patients who had undergone a THA at a single University Medical Center, as well as two regional hospitals in the Netherlands. More studies from other hospitals and countries are needed. As a first step, we just started a prospective study into the physical activity behavior of patients after primary THA in two hospitals in Germany and the United Kingdom.

Furthermore, the studies presented in this thesis do not provide insight into the development of the physical activity behavior from the preoperative situation into the postoperative period. Studies evaluating the physical activity behavior of patients preoperatively and after THA could delineate the effects of THA on physical activity behavior and provide insight into the development of physical activity in the course of time after the operation. At present, information on the physical activity behavior of patients before and at different moments after the operation is being collected at our department, so that a first insight into this development will become available in the near future. In the summer of 2008 this collection of data will become computer-based. An online data management system will become available at the outpatient clinic of the orthopedic department of UMCG. This will make it possible to follow the patients in a prospective way. In the future it may become possible to incorporate data from body-fixed sensors into this system.

In this thesis only the influence of demographic patient characteristics on physical activity behavior after THA was determined. As physical activity behavior in the general adult population is known to be influenced by a large variety of other determinants, such as psychological, behavioral, social and environmental factors,[9] more investigation into the role of these determinants with respect to physical activity behavior of patients after THA is needed. Given the large proportion of patients after THA who are still insufficiently physically active, the development and subsequent implementation of a physical activity intervention strategy targeting these patients should be strongly considered. This strategy should be implemented and evaluated in terms of participation rates and effects on energy expenditure, health and fitness outcomes in the short and the long term, and cost effectiveness.

As has been done in other countries (e.g. the United States)[57] it would be of great interest to conduct a survey among orthopedic surgeons in the Netherlands to analyze their preferences and the advice they give to patients regarding physical activity after THA. Based on the results of such a survey, and surveys already conducted in other countries, consensus guidelines can be developed which will be needed to provide patients with clear instructions on the physical activities they can safely perform without jeopardizing the implanted hip prosthesis.

It would also be of great interest to explore the clinical usefulness of the SQUASH for the assessment of physical activity from the traditional perspective of it being an important determinant of prosthetic wear, loosening and survival. In that respect it would be very interesting if differences in physical activity level between patients, as assessed by the SQUASH, could be consistently and reliably linked to observed differences in wear, loosening and survival of hip prostheses. In this way the SQUASH would fulfill the need for an adequate assessment tool serving this goal, since accounting for the physical activity level of patients must be considered to be a crucial step in the survivorship analysis of THA as well as when comparing the results of procedures performed under different surgical approaches (e.g. traditional vs. minimally invasive) or with different prosthetic designs or bearing couples.[58,59] In this context it would also be of great interest to explore the clinical usefulness of body-fixed-sensor based technology, such as accelerometers, as a more objective tool to assess physical activity. This technology could also provide more insight into the joint loading occurring during physical activity, as well as an objective insight into the physical functioning of patients after THA. This information could not only be used to assess the outcome of THA, but could also be used to tailor physical activity intervention strategies, as well as postoperative rehabilitation schemes to the needs of the patient.

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Summary

Regular physical activity plays an important role in the primary and secondary prevention of several chronic conditions, and is linked to a reduction in all-cause mortality. It also enhances musculoskeletal fitness. Through these effects, regular physical activity can make an important contribution to maintaining the health and health-related quality of life of people of all ages. Additionally, it can help counter the functional declines associated with aging, thereby contributing to the maintenance of the functional autonomy of an aging population in Western society. The recognition of these beneficial effects in society has resulted in the issuing of guidelines for health-enhancing physical activity as well as numerous public campaigns to promote physical activity, as large proportions of the general population are insufficiently physically active.

Despite these developments, little is still known about the physical activity behavior of a large and growing subset of the population: patients after total hip arthroplasty (THA). Studies addressing physical activity in these patients have mainly pertained to sports and walking activity, or have only used scoring tools like the UCLA activity score to categorize level of physical activity, but have failed to provide detailed insight into the physical activity behavior of patients after THA. Furthermore, these studies have focused mainly on the determination of realistic loading conditions for hip prostheses and the implication of certain activities on implant survival, as well as on the return to specific activities after THA, but not on the beneficial effects of regular physical activity. In order to provide more detailed insight into the physical activity behavior of patients after THA, this thesis addressed physical activity after THA, with a focus on the assessment of physical activity from the perspective of its beneficial effects on health and musculoskeletal fitness. In the end, more insight into this behavior will also allow for a better and fairer comparison of the results of surgical procedures performed with different surgical approaches (e.g. minimally invasive versus traditional), different prostheses and/or different bearing couples.

Chapter 2 describes the interrelationships between physical activity, health-related fitness and health using the Bouchard model. An extensive description is given of the beneficial effects of regular physical activity on health and musculoskeletal fitness, as well as of the negative effects of physical inactivity. The current recommendations for health-enhancing physical activity for adults as well as for older adults in the general population are outlined. Subsequently, the pros and cons of physical activity in patients after THA are discussed and current exercise recommendations after THA described. An overview is given of the current knowledge on the physical activity behavior of patients after THA, showing that detailed information regarding the habitual physical activity behavior of these patients is lacking. Methods to assess this behavior are described.

Chapter 3 determines the predictive value of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) for level of physical activity after THA. The WOMAC is one of the most widely used disease-specific outcome instruments in people

with osteoarthritis. Although this outcome instrument does not provide direct information about level of physical activity, it was hypothesized that when patients experience more pain, stiffness and limitations in physical functioning as measured by the WOMAC, this will have an adverse effect on the amount of physical activity they can perform. In this way the WOMAC score of patients could possibly predict the amount of physical activity they perform. For that reason we calculated the Pearson correlation coefficients between the total score on the WOMAC and scores on the Short QUestionnaire to Assess Health-enhancing Physical Activity (SQUASH). The SQUASH is a self-reported questionnaire that measures habitual physical activity level, and is structured in a way that allows the results to be compared with national and international physical activity guidelines. It is used by Dutch government agencies to monitor the physical activity behavior of the general Dutch population. Additionally, the extent to which the WOMAC score could predict that patients would meet the physical activity guidelines was determined using binary logistic regression modeling. The eventual study population consisted of 364 patients with a mean age of 64 years. Correlations between the total score on the WOMAC and the subscale and total scores on the SQUASH varied between 0.14 and 0.24, and must be considered low. Although the WOMAC score was found to be a significant predictor for meeting the guidelines, the odds ratio was low (1.022) and only 6.9% of the variance could be explained. Based on these findings it was concluded that the use of additional measures is needed, as the WOMAC is clinically not suitable to predict level of physical activity or compliance with the guidelines for health-enhancing physical activity of patients after THA.

In **Chapter 4** we determine if the SQUASH can be used to assess the habitual physical activity behavior of patients after THA. For that reason, the reliability of the SQUASH was determined in a population of 44 patients (mean age 71 years). Validity of the SQUASH was determined in 39 of these 44 patients (mean age 70 years), using an Actigraph™ accelerometer as criterion measure. Spearman's correlation coefficient for overall reliability was 0.57, and varied between 0.45 and 0.90 for the separate questions of the SQUASH. No systematic biases were found between readings. The Spearman correlation between Actigraph™ readings and total activity score was 0.67. These values are in line with those found in a previous study into the measurement properties of the SQUASH, in a healthy adult population. They are also in line with values found in other physical activity questionnaires. However, systematic bias was found between the scores on the SQUASH and the Actigraph™ readings. Therefore further analysis of the validity of the SQUASH is needed. We concluded that the SQUASH can be considered to be a fairly reliable tool to assess the habitual physical activity behavior of patients after THA, with validity comparable to the validity of other physical activity questionnaires. As the SQUASH is short and easy to fill in it may prove to be a useful instrument to assess the physical activity behavior of patients after THA.

Chapter 5 presents the results of a cross-sectional study into the habitual physical activity behavior of patients after THA. By using the SQUASH, amount of physical activity as well as compliance with the guidelines for health-enhancing physical activity were assessed in a population of 273 patients (mean age 63 years) at least one year after primary THA. Results were compared with an age- and gender-matched norm population. To assess the potential influence of patients' age or additional functional impairments on physical activity level, comparisons were made between patients aged <65 and those aged ≥65, and between patients in different Charnley classes.

The study revealed that there were no significant differences in total amount of physical activity or in time spent in different categories of physical activity between patients after THA and the norm population. Patients after THA spent significantly more minutes in activities of moderate intensity than people in the norm population. Patients aged <65 were significantly more active than older patients. Charnley class had significant effects on time spent at work, time spent in moderate-intensity activities and total amount of physical activity, with the least activity performed by patients in Charnley class C. The guidelines were met by 51.2% of patients after THA and 48.8% of the norm population. This difference was not significant. Gender was found to be the only variable that significantly influenced the chance of meeting the guidelines. The chance of men meeting the guidelines was about twice the chance of women meeting them. Age of the patient, number of comorbidities and Charnley class did not significantly influence the chance of meeting the guidelines. It was concluded that patients after THA appear to be at least as physically active as a norm population. At the same time, this result means that a large percentage of these patients still failed to meet the guidelines.

Chapter 6 studies more extensively the influence of aspects of patient characteristics (age, gender, family status, education, general comorbidity and Charnley class) on level of physical activity in the previously described cohort of 273 patients after THA (Chapter 5). Knowledge of these patient characteristics allows the identification of patients at risk of a physically inactive lifestyle. Increasing age, lower education and living alone were found to be associated with a physically inactive lifestyle. Only gender predicted meeting the guidelines of health-enhancing physical activity significantly, with males meeting the guidelines about twice as often as females.

In **Chapter 7** we present the results of a prospective, multicenter study into the physical activity behavior of 653 patients (mean age 70.3 years) one year after primary THA. Subanalyses were performed in different age groups (ages <55, 55-75 and >75) and determinants of physical activity were assessed. Additionally, compliance with guidelines of health-enhancing physical activity as well as determinants of compliance with these guidelines were assessed.

Patients were found to spend most of the time in household and leisure-time physical activity, while activities were mostly of light intensity. Younger patients were significantly more active physically than older patients. The participation of patients aged <55 in activities at work contributed largely to this higher activity level of older patients. Age of the patient and body mass index (BMI) significantly predicted patients' level of physical activity, with younger patients and patients with a lower BMI showing higher activity levels. Patients complied with the guidelines in 67% of cases. This percentage was 52.3% for patients aged <55, 71.8% for patients aged 55-75 and 55.1% for patients aged >75. These percentages appear to be in line with those found in the general Dutch population. Age of the patient, gender and the presence of complaints in the lower extremities significantly predicted compliance with the guidelines. Males, patients without complaints in the lower extremity, and to lesser extent younger patients had a greater chance of meeting these guidelines.

Chapter 8 is a general discussion in which the assessment of physical activity within an orthopedic context is examined in more detail. Pros and cons of self-reported questionnaires such as the SQUASH, as well as the role of body-fixed-sensors-based technology such as accelerometers as a more objective method to assess physical activity were outlined. The promotion of physical activity was also discussed. Although the results of the studies presented in this thesis have shown that patients after THA appear to be as physically active as a norm population, large percentages of these patients are still insufficiently physically active. Therefore, these patients should be stimulated to become physically more active. An overview was given of current knowledge about the effectiveness of intervention strategies to promote physical activity in the general population, as well as of the effectiveness of PACE and GALM, as examples that have been applied in the Netherlands. The promotion of physical activity in an orthopedic context was discussed. Finally, suggestions for future research were given.

Samenvatting

Regelmatige lichamelijke activiteit speelt een belangrijke rol in de primaire en secundaire preventie van verschillende chronische aandoeningen, en vermindert de kans op voortijdig overlijden. Bovendien heeft regelmatige lichamelijke activiteit positieve effecten op de conditie van het houdings- en bewegingsapparaat. Door deze effecten kan regelmatige lichamelijke activiteit een belangrijke bijdrage leveren aan het behoud van gezondheid en de gezondheidsgerelateerde kwaliteit van leven van personen van alle leeftijden. Bovendien kan het helpen de functionele achteruitgang, zoals die met het ouder worden optreedt, tegen te gaan en daardoor bijdragen aan het behoud van de functionele autonomie van personen in een vergrijzende westerse samenleving. De maatschappelijke bewustwording van deze positieve effecten van lichamelijke activiteit heeft geleid tot het opstellen van richtlijnen voor gezondheidsbevorderende lichamelijke activiteit, zoals de Nederlandse norm gezond bewegen. Aangezien een groot deel van de Nederlandse bevolking onvoldoende lichamelijk actief is heeft deze bewustwording tevens geleid tot talrijke campagnes om lichamelijke activiteit in de algemene bevolking te bevorderen.

Ondanks deze ontwikkelingen is er nog weinig bekend over het lichamelijke activiteiten patroon van een grote en groeiende subgroep binnen de algemene bevolking: patiënten na een totale heup artroplastiek (THA). Studies naar lichamelijke activiteit verricht door deze patiënten beperken zich vooral tot sport en wandel activiteiten, of gebruiken scores, zoals de UCLA activiteiten score, die slechts het niveau van lichaamsbeweging bepalen. Tot dusver hebben deze studies echter een onvoldoende gedetailleerd inzicht gegeven in het lichamelijke activiteiten patroon van patiënten na een THA. Bovendien was de aandacht in deze studies niet gericht op de positieve effecten van regelmatige lichamelijke activiteit, maar vooral op het bepalen van de mate van belasting waaraan heupprothesen worden blootgesteld, het bepalen van de invloed van specifieke activiteiten op de overlevingsduur van de prothese, alsook op het hervatten van specifieke activiteiten na de operatie. Om toch een beter inzicht te verkrijgen in het lichamelijke activiteiten patroon van patiënten na een THA heeft dit proefschrift zich gericht op de lichamelijke activiteit van patiënten na een THA, waarbij deze lichamelijke activiteit voornamelijk werd bepaald in het kader van de positieve effecten op gezondheid en fitheid. Uiteindelijk zal een beter inzicht in dit lichamelijke activiteiten patroon ook een betere en eerlijker vergelijking mogelijk maken van de resultaten van operaties uitgevoerd via verschillende chirurgische benaderingen (zoals minimaal invasief versus traditioneel) en van operaties uitgevoerd met verschillende prothesen en/of verschillende articulatie materialen.

In **hoofdstuk 2** wordt de relatie tussen lichamelijke activiteit, lichamelijke fitheid en gezondheid beschreven met behulp van het Bouchard model. De positieve effecten van regelmatige lichamelijke activiteit op gezondheid en fitheid, alsook de negatieve effecten van lichamelijke inactiviteit, worden uitvoerig beschreven. De huidige richtlijnen voor gezondheidsbevorderende lichamelijke activiteit voor volwassenen en voor oudere volwassenen in de algemene bevolking worden weergegeven. Vervolgens worden de voor- en nadelen van lichamelijke activiteit bij patiënten na een THA en de huidige aanbevelingen ten aanzien van lichamelijke activiteit na een THA beschreven. Er wordt een overzicht gegeven van het huidige inzicht in het lichamelijke activiteiten gedrag van patiënten na een THA. Hieruit wordt duidelijk dat gedetailleerde informatie met betrekking tot de lichamelijke activiteit uitgevoerd door deze patiënten ontbreekt. Vervolgens worden verschillende methoden beschreven om de mate van lichamelijke activiteit te bepalen.

In **hoofdstuk 3** wordt bepaald in hoeverre de Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) kan worden gebruikt om de hoeveelheid lichamelijke activiteit na een THA te voorspellen. De WOMAC is één van de meest gebruikte ziekte-specifieke uitkomstmaten bij personen met artrose. Hoewel deze uitkomstmaat geen directe informatie geeft over de hoeveelheid lichamelijke activiteit, kan de hypothese worden opgesteld dat wanneer patiënten meer pijn, stijfheid en beperkingen in het fysieke functioneren ervaren, zoals gemeten met behulp van de WOMAC, dit een negatief effect zal hebben op de hoeveelheid lichamelijke activiteit die zij kunnen uitvoeren. Op deze manier zou de WOMAC score mogelijk gebruikt kunnen worden om een inschatting te maken van de hoeveelheid lichamelijke activiteit uitgevoerd door patiënten na een THA. Om deze reden werden de Pearson correlatie coëfficiënten tussen de totale score op de WOMAC en de scores op de "Short Questionnaire to Assess Health-enhancing Physical Activity" (SQUASH) berekend. De SQUASH is een door de patiënt zelf ingevulde vragenlijst die de dagelijkse lichamelijke activiteit vastlegt. De vragenlijst is zodanig gestructureerd dat de resultaten vergeleken kunnen worden met nationale en internationale richtlijnen voor voldoende lichamelijke activiteit en wordt gebruikt door Nederlandse overheidsinstanties om het bewegingsgedrag van de Nederlandse bevolking te monitoren. Daarnaast werd met behulp van binaire logistische regressie bepaald in hoeverre de WOMAC score kon voorspellen of patiënten voldeden aan de richtlijnen voor voldoende lichamelijke activiteit. De uiteindelijke studiepopulatie bestond uit 364 patiënten met een gemiddelde leeftijd van 64 jaar. De correlaties tussen de totale score op de WOMAC en de sub- en totale scores op de SQUASH varieerden tussen de 0.14 en 0.24, en moeten daarom als laag worden beschouwd. Hoewel de WOMAC score een significante voorspeller bleek te zijn voor het voldoen aan de richtlijnen, was de odds ratio laag (1.022) en kon slechts 6.9 % van de variantie worden voorspeld. Op basis van deze bevindingen werd geconcludeerd dat de WOMAC klinisch niet geschikt is om de hoeveelheid lichamelijke activiteit of het voldoen aan de richtlijnen voor voldoende lichamelijke activiteit te voorspellen, zodat het nodig is hiervoor een ander meetinstrument te gebruiken.

In **hoofdstuk 4** bepalen we of de SQUASH kan worden gebruikt om de dagelijkse lichamelijkeactiviteit van patiënten na een THA te meten. Hiertoe werd de betrouwbaarheid van de SQUASH bepaald in een populatie van 44 patiënten (gemiddelde leeftijd 71 jaar). De validiteit van de SQUASH werd bepaald bij 39 van deze 44 patiënten (gemiddelde leeftijd 70 jaar), waarbij een Actigraph™ versnellingsmeter als referentie maat werd gebruikt. De Spearman correlatie coëfficiënt voor de betrouwbaarheid was 0.57, en varieerde tussen de 0.45 en 0.90 voor de afzonderlijke vragen van de SQUASH. Er werd geen systematische bias gevonden. De Spearman correlatie coëfficiënt tussen de Actigraph™ registraties en de totale activiteiten score van de SQUASH was 0.67. Deze waarden komen overeen met die welke gevonden werden in een eerdere studie naar de betrouwbaarheid en validiteit van de SQUASH, uitgevoerd in een gezonde volwassen populatie. Zij komen ook overeen met de waarden gevonden bij andere lichamelijke activiteiten vragenlijsten. Er werd echter wel een systematische bias gevonden tussen de uitkomsten van de SQUASH en de Actigraph™, waardoor meer onderzoek nodig is naar de validiteit van de SQUASH. Geconcludeerd werd dat de SQUASH kan worden beschouwd als een redelijk betrouwbaar instrument om het dagelijkse lichamelijke activiteiten patroon van patiënten na een THA te bepalen, waarbij de validiteit vergelijkbaar is met andere vragenlijsten. Omdat de SQUASH kort is en gemakkelijk ingevuld kan worden door patiënten, kan deze vragenlijst mogelijk een bruikbaar instrument zijn om het lichamelijke activiteiten patroon van patiënten na een THA te bepalen.

In **hoofdstuk 5** worden de resultaten van een cross-sectionele studie naar het lichamelijke activiteiten patroon van patiënten na een THA gepresenteerd. Met gebruikmaking van de SQUASH werd de hoeveelheid lichamelijke activiteit, alsook het voldoen aan de richtlijnen voor gezondheidsbevorderende lichamelijke activiteit bepaald in een populatie van 273 patiënten (gemiddelde leeftijd 63 jaar) die tenminste 1 jaar eerder een THA ondergingen. De resultaten werden vergeleken met een op leeftijd en geslacht gematchede normpopulatie. Om de potentiële invloed van de leeftijd van de patiënt en de invloed van additionele functionele beperkingen op het lichamelijke activiteiten niveau te bepalen, werden bovendien vergelijkingen gemaakt tussen patiënten < 65 jaar en ≥ 65 jaar, en tussen patiënten in verschillende Charnley klassen.

De studie liet geen significante verschillen zien in de totale hoeveelheid lichamelijke activiteit, noch in de tijd doorgebracht in de verschillende categorieën van lichamelijke activiteit, tussen patiënten na een THA en de normpopulatie. Patiënten na een THA brachten significant meer minuten door in activiteiten van matige intensiteit vergeleken met mensen in de normpopulatie. Patiënten < 65 jaar waren significant actiever dan oudere patiënten. De Charnley klasse had significante effecten op de tijd doorgebracht op het werk, op de tijd doorgebracht in matig intensieve activiteiten en op de totale hoeveelheid lichamelijke activiteit, waarbij patiënten in Charnley klasse C het minste actief waren. Patiënten na een THA voldeden in 51.2% van de gevallen aan de richtlijnen, terwijl dit percentage 48.8% was voor de normpopulatie. Dit verschil was niet significant. Het geslacht van de patiënt was de enige variabele met een significante invloed op de kans om aan de richtlijnen te voldoen. De kans dat mannen voldeden aan de richtlijnen was ongeveer twee keer zo groot als de kans dat vrouwen hieraan voldeden. De leeftijd van de patiënt, de mate van co-morbiditeit en de Charnley klasse hadden geen significante invloed. Op basis van deze resultaten werd geconcludeerd dat patiënten na een THA tenminste zo lichamelijk actief lijken te zijn als een norm populatie. Dit betekent echter tegelijkertijd dat toch een groot percentage van deze patiënten niet voldoet aan de richtlijnen.

In **hoofdstuk 6** wordt de invloed van verschillende patiënt kenmerken (leeftijd, geslacht, gezinssituatie, opleiding, algemene co-morbiditeit en Charnley klasse) op het niveau van lichamelijke activiteit uitgebreider bestudeerd in het eerder beschreven cohort van 273 patiënten na een THA (hoofdstuk 5). Kennis van deze patiënt kenmerken maakt het mogelijk patiënten te identificeren die een risico lopen op een lichamelijk inactieve levensstijl. Een hogere leeftijd, lager opleidingsniveau en een alleenstaande gezinssituatie waren geassocieerd met een lichamelijk inactieve levensstijl. Alleen geslacht had een significant voorspellende waarde voor het voldoen aan de richtlijnen, waarbij mannen ongeveer twee keer zo vaak voldeden aan de richtlijnen als vrouwen.

In **hoofdstuk 7** worden de resultaten gepresenteerd van een prospectieve, multicenter studie naar het lichamelijke activiteiten gedrag van 653 patiënten (gemiddelde leeftijd 70.3 jaar) 1 jaar na een primaire THA. Er werden subanalyses uitgevoerd in verschillende leeftijdsgroepen (< 55 jaar, 55-75 jaar en > 75 jaar) en determinanten van lichamelijke activiteit werden bepaald. Daarbij werd de mate waarin patiënten voldeden aan de richtlijnen voor gezondheidsbevorderende lichamelijke activiteit, alsook de determinanten voor het voldoen aan deze richtlijnen bepaald.

Patiënten bleken de meeste tijd door te brengen in huishoudelijke- en vrije tijd activiteiten, waarbij de activiteiten vooral in de lichte intensiteit categorie werden uitgevoerd. Jongere patiënten waren significant actiever dan oudere patiënten. De arbeidsparticipatie van patiënten < 55 jaar droeg voor een belangrijk deel bij aan dit hogere activiteiten niveau van jongere patiënten. Leeftijd van de patiënt en body mass index (BMI) hadden een significant voorspellende waarde voor het niveau van lichamelijke activiteit, waarbij jongere patiënten en patiënten met een lagere BMI een hoger activiteiten niveau lieten zien. Patiënten voldeden in 67% van de gevallen aan de richtlijnen. Dit percentage bedroeg 52.3% voor patiënten < 55 jaar, 71.8% voor patiënten tussen de 55 en 75 jaar en 55.1% voor patiënten > 75 jaar. Deze percentages komen overeen met de percentages zoals die in de algemene Nederlandse populatie worden gevonden. Leeftijd van de patiënt, geslacht en de aanwezigheid van klachten aan de onderste extremiteiten voorspelden op een significante wijze de mate waarin aan de richtlijnen werd voldaan.

Mannen, patiënten zonder klachten van de onderste extremiteiten, en in mindere mate jongere patiënten hadden een grotere kans om aan de richtlijnen te voldoen.

In de algemene discussie (**hoofdstuk 8**) wordt dieper ingegaan op het meten van lichamelijke activiteit in een orthopedische context. De voor- en nadelen van door de patiënt ingevulde vragenlijsten, zoals de SQUASH, alsook de rol die technologie gebaseerd op aan het lichaam bevestigde sensoren, zoals versnellingsmeters, als meer objectieve methoden om lichamelijke activiteit vast te leggen worden beschreven. Bovendien wordt ingegaan op het stimuleren van lichamelijke activiteit. Hoewel de resultaten van de studies gepresenteerd in dit proefschrift hebben laten zien dat patiënten na een THA lichamelijk even actief lijken te zijn als mensen in een normpopulatie, is een groot percentage van deze patiënten toch nog onvoldoende lichamelijk actief. Dit betekent dat deze patiënten gestimuleerd zouden moeten worden om lichamelijk actiever te worden. Er wordt een overzicht gegeven van de huidige kennis over de effectiviteit van interventie strategieën om lichamelijke activiteit in de algemene bevolking te stimuleren, alsook van de effectiviteit van PACE en GALM, als voorbeelden van interventie strategieën welke zijn toegepast in Nederland. Vervolgens wordt het stimuleren van lichamelijke activiteit in een orthopedische context besproken. Tot slot worden suggesties voor toekomstig onderzoek gegeven.

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Curriculum Vitae

The author of this thesis was born on the 23rd of August 1968 in Assen, The Netherlands. In 1986 he finished high school (VWO, RSG Leeuwarden) and started his medical study at the University of Groningen. After graduating in 1993 he fulfilled his military duty. During this period, from 1993-1994, he worked as a military doctor for the Multinational Forces and Observers (MFO) in the Sinai desert, Egypt. After return in The Netherlands he worked as a surgical resident at the Streekziekenhuis Midden-Twente Hengelo, and at the Spaarneziekenhuis Haarlem. In 1997 he started his surgical training at the Medisch Spectrum Twente Enschede (head: Prof. Dr. P.A.M. Vierhout), as part of the training to become an orthopedic surgeon. The orthopedic part of this training was done at the Academisch Ziekenhuis Groningen (head: Prof. Dr. J.R. van Horn) and at the Deventer Ziekenhuizen (head: Dr. A.P.P.M. Driessen). In 2003 he completed his training and since then he works as an orthopedic surgeon at the University Medical Center Groningen (former Academisch Ziekenhuis Groningen; head: Prof. Dr. S.K. Bulstra). He lives together with Esther Wildenbeest. Together they have 2 children: Esmée and Casper.

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