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BODY FAT, FITNESS AND LEVEL OF EVERYDAY PHYSICAL ACTIVITY IN ADOLESCENTS AND YOUNG ADULTS WITH MENINGOMYELOCELE

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Objective: **Data on body fat and fitness in adolescents and young adults with meningomyelocele are scarce. The aim of this study was to assess body fat and fitness in this patient group. In addition, we explored whether the level of everyday physical activity is related to body fat and fitness.**
Subjects and methods: **Body fat (skinfold thickness), fitness (VO_{2peak}), and everyday physical activity (Activity Monitor, based on accelerometry) were measured in 14 patients with meningomyelocele (8 men, 6 women; age range 14–26 years).**
Results: **Peak VO_2 was 20–30% lower than reference values and 4 patients were obese. Level of everyday activity was related to fitness ($r_s = 0.65$, $p = 0.01$) but not to body fat.**
Conclusion: **Young patients with meningomyelocele are at risk for developing obesity and have a distinctly subnormal fitness. Level of everyday physical activity is related to fitness in this patient group.**

Key words: body fat, fitness, physical activity, meningomyelocele.

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INTRODUCTION

In the Netherlands, meningomyelocele (MMC), together with cerebral palsy, is the most common physically disabling condition of childhood, with a live birth prevalence of 4.6 (1994–96) to 3.8 (1997–98) per 10,000 (1). Due to loss of motor function, patients with MMC are restricted in the performance of normal everyday activities. Inherently, these patients are at risk of developing a hypoactive lifestyle, e.g. patients may have to go to school or work by car or taxi, possibilities for sports activities are not always optimal and patients are often confined to sedentary jobs. A negative spiral may then gradually develop: hypoactivity leading to a reduction in physical fitness and increase in body fat, leading to further hypoactivity. Besides detrimental effects on daily functioning, hypoactivity may increase the chance for developing coronary heart disease later in life (2–4). Furthermore, it can be assumed that everyday physical activity is related to the quality of life (5, 6).

In a previous study (7) we found that adolescents and young adults with MMC (both ambulators and non-ambulators, but particularly the non-ambulators) are considerably hypoactive as measured with an Activity Monitor (AM). The percentage of a 24-hour period that patients with MMC performed dynamic activities (walking, wheelchair-driving, cycling or general (non-cyclic) movement) was 6.5 (2.3)%, whereas this percentage was 6.5 (2.3)% and 12.7 (4.3)% in their healthy peers ($p < 0.001$). Bandini et al. (8) reported that the ratio of total energy expenditure to resting metabolic rate, which is an index for the level of everyday physical activity, was subnormal in non-ambulatory adolescents with MMC (1.20 (0.22) vs 1.76 (0.25), $p < 0.01$). Besides these low levels of everyday physical activity that are described in MMC, obesity has been reported in this population (8–11), and the physical fitness has been found to be distinctly subnormal (12–14). It can be hypothesized that low levels of everyday physical activity are (partly) responsible for obesity and low physical fitness in patients with MMC.

Because the data on body fat and particularly on fitness in adolescents and young adults with MMC are scarce, the primary aim of the study was to assess body fat and fitness in adolescents and young adults with MMC. Furthermore, we explored whether these parameters differ between ambulatory patients and non-ambulatory patients, and we explored whether the level of everyday physical activity is related to body fat and fitness in this patient group (secondary aims).

METHOD

Patients

Exclusion criteria for the study were complete dependence on an electric wheelchair, presence of disorders other than MMC that affect daily physical activity, and presence of disorders that contra-indicate a maximal exercise test. Patients ($n = 24$) with MMC from Rijndam Rehabilitation Center and Erasmus Medical Center (both in Rotterdam) were asked to participate; 58% of subjects agreed to participate (8 men, 6 women; age range 14–26 years). Reasons for non-participation were dislike of a long-lasting (48-hour) measurement with the AM ($n = 2$), need for surgery during the research period ($n = 1$) and school obligations elsewhere in the country ($n = 1$). Furthermore, the parents of 1 child did not consent because they felt that their child was unable to understand the impact of the study and in 5 patients the reason was unknown (these patients did not respond to our letters). There were no differences in relevant characteristics between the patients who participated and patients who decided not to participate. The subjects

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and (if applicable) their parents were informed of all aspects of the study and written consent was obtained. The study was approved by the Medical Ethics Committee of the Erasmus Medical Center.

Measures

General. Because 5 patients (36%) were allergic to latex, all measurements were performed with latex-free products. Information on neurological level of the lesion was obtained from the patients' record. Ambulatory status was divided into 4 categories according to the classification of Hoffer et al. (15), and assigned scores: community ambulator: walks indoors and outdoors for most of the activities (score 4); household ambulator: walks only indoors (score 3); non-functional ambulator: walks only during therapy sessions (score 2); non-ambulatory: wheelchair-bound (score 1). Body mass was obtained while sitting (without shoes) on an electronic scale (Cormier, France). Height measurements were made with a flexible tape with subjects lying on a bed. In case of contractures, measurements were performed from joint to joint. Arm span was measured from the tip of the right middle finger to the tip of the left middle finger, with the arms fully in extension in 90 degrees abduction.

Body fat. Thickness of 4 skinfolds (biceps, triceps, subscapular, suprailiac) was measured twice on the right side of the body with a Harpenden caliper (Burgess Hill, UK). The mean of the 2 measurements was used as representative for each site. Percentage body fat (BF) was predicted from skinfold thickness according to the method of Durnin & Rahaman (16) in subjects aged 14 or 15 years and according to the method of Durnin & Womersley (17) in the older subjects. Cut-off points of $>$25% BF for males and $>$32% BF for females were used to assess obesity (18).

Fitness. Fitness was measured in a progressive maximal aerobic test (based on the McMaster All-Out Progressive Continuous Cycling and Arm Test (19) on an electronically braked arm or cycle ergometer (Jaeger ER800SH and ER800 respectively; Jaeger Toennies, Breda, The Netherlands). Bhambhani et al. (20), studying patients with cerebral palsy who were partly wheelchair-dependent, concluded that maximal exercise testing during the main mode of ambulation elicits the highest VO_2 uptake. Therefore, depending on their main mode of ambulation, patients performed an arm crank test ($n = 8$) while sitting in their own immobilized wheelchair (cranks at shoulder height), or a leg cycle test ($n = 6$). The test was preceded by a 3-minute warm-up (5 watt for arm ergometry, 20 watt for cycle ergometry), followed by a resting period of 5 minutes while sitting on a (wheel)chair. During the test, resistance was increased every 2 minutes with a variable load, depending on the ability of the subject. Individual protocols were constructed such that the total exercise time ranged from 8 to 12 minutes. The pedal/crank rate for both the arm and leg tests was 60 rpm and strong verbal encouragement was given throughout the test. The test was terminated when the subject voluntarily stopped owing to exhaustion, or when the subject was unable to maintain the initial pedal/crank rate. Gas exchange and heart rate (HR) were determined continuously using a breath-by-breath portable measurement system ($K4b^2$, COSMED, Rome, Italy). Fitness was defined as the mean oxygen uptake during the last minute of exercise (VO_{2peak}). Heart rate and respiratory exchange ratio (RER) were used as objective criteria for maximal exercise. Subjective strain was measured at the end of the final stage by the Borg Category Scale for Rating of Perceived Exertion (21). The night before the test, subjects consumed no alcohol. On the day of the measurement, subjects refrained from caffeine, nicotine, and heavy exercise.

Level of everyday physical activity. For the assessment of everyday physical activity an Activity Monitor (AM, Temec Instruments, Kerkrade, The Netherlands; size $15 \times 9 \times 3.5$ cm; weight 500 g) was used. Briefly, the AM is based on long-term ambulatory monitoring of signals from body-fixed accelerometers during everyday life, aimed at the assessment of mobility-related activities (22). Information can be obtained on which postures (lying, sitting, standing), movements (walking, cycling, wheelchair-driving, general movement) and transitions between postures are performed, when, how often, and for how long. The AM consists of accelerometers (sensors), a portable data recorder and a computer with analysis programs. Validity studies in healthy subjects and several patient groups, in which simultaneously made video registrations (reference method) were compared with the outcome of the AM, have shown that the AM is valid to quantify mobility-related activities (22). Furthermore, the AM can detect differences in everyday activity between groups (7, 23) which supports its validity and applicability in clinical research.

Measurements with the AM were performed during 2 randomly selected consecutive week days (48-hour measurement). To achieve minimal interference with the normal everyday activity patterns, subjects were fitted with the AM at home. During the activity monitoring, subjects were not allowed to swim or take a shower or bath. To avoid measurement bias, the principles of the AM were explained to the subjects only after the measurements. All subjects agreed with this procedure.

Four IC-3031 uniaxial piezo-resistive accelerometers were used (about $1.5 \times 1.5 \times 1$ cm) and attached to the sternum and thigh, and in wheelchair-dependent patients also to the wrist; a detailed description of the configuration of the sensors can be found elsewhere (7). The accelerometers were connected to the AM, which was worn in a padded bag around the waist. Accelerometer signals were stored digitally on a PCMCIA flash card with a sampling frequency of 32 Hz. After the measurement, data were downloaded onto a computer for analysis by the Signal Processing and Inferencing Language (24). A detailed description of the activity detection procedure can be found elsewhere (22). Briefly, from each measured signal, 3 feature signals are derived (1 Hz): an angular feature signal, a motility feature signal, and a frequency feature signal. For consecutive moments in time (each second), and for each activity category, the distance between the actual feature signal values and activity-specific ranges that are pre-set is calculated. For each activity, the calculated distances of the feature signals are added and the activity with the shortest distance is selected. Wheelchair-driving was determined with a post-analysis program, also using distance criteria.

Statistical analysis

Data are presented as mean (SD) for the whole study population, and for the subgroups ambulatory patients (household ambulators and community ambulators) and non-ambulatory patients (non-ambulators and non-functional ambulators). Only the primary AM output parameter "duration of the day spent on dynamic activities", which is a composite measure of walking, wheelchair-driving, cycling and general movement, was included in the analyses to explore whether the level of everyday physical activity is related to BF (percentage BF, obesity [dichotomised parameter]) and fitness (VO_{2peak}). Further aspects of everyday physical activity as measured with the AM in the MMC population are presented elsewhere (7). Comparisons between data were made using the Wilcoxon test for paired observations, and the Mann-Whitney U test for unpaired observations. Using the Spearman correlation coefficient we investigated the relationships between parameters. All statistics were done with SPSS 9.0 for Windows. A probability value $\leq$0.05 determined statistical significance.

RESULTS

Patients

Table I shows the characteristics of the patients, including neurological level and ambulatory status. Two patients (A and F) used medication on a daily basis (bladder control) and 3 patients (E, H and M) used medication only incidentally (bladder control, urinary tract infections, latex allergy). According to the classification of functional ambulation of Hoffer et al. (15), 9 patients were ambulatory (household ambulator $n = 6$, community ambulator $n = 3$) and 5 patients were non-ambulatory. Mean (SD) age of the patients was 18 (4) years, mean (SD) height was 156 (16) cm, mean (SD) armspan was 169 (13) cm, and mean (SD) body mass was 61.7 (23.4) kg.

Table I. *Characteristics of the 14 patients*

Pat / Sex	Neurological level	History of hydrocephalus*	Ambulatory status†
A / F	Lumbar/sacral	+	Household ambulator
B / M	Lumbar/sacral	+	Household ambulator
C / M	Lumbar/sacral	−	Non-ambulator
D / M	Lumbar/sacral	−	Community ambulator
E / F	Lumbar	+	Household ambulator
F / F	Sacral	+	Household ambulator
G / M	Lumbar	+	Community ambulator
H / F	Lumbar	−	Non-ambulator
I / M	Lumbar/sacral	+	Non-functional ambulator
J / M	Lumbar/sacral	+	Household ambulator
K / M	Lumbar/sacral	+	Household ambulator
L / F	Thoracic/lumbar	−	Non-ambulator
M / F	Thoracic/lumbar	+	Non-ambulator
N / M	Lumbar/sacral	+	Community ambulator

*+ present, − absent. † According to Hoffer et al. (15): "Community ambulators" walk indoors and outdoors for most of their activities and may need crutches or braces, or both. They use a wheelchair only for long trips out of the community. "Household ambulators" walk only indoors and with apparatus. They are able to get in and out of the chair and bed with little if any assistance. They may use the wheelchair for some indoor activities at home and school, and for all activities in the community. "Non-functional ambulators" only walk during therapy sessions at home, in school, or in the hospital. Afterward they use their wheelchairs to get from place to place and to satisfy all their needs for transportation. "Non-ambulators" are wheelchair-bound but usually can transfer from chair to bed.

Table II. *Body fat and fitness (mean (SD)) of 14 patients with meningomyelocele*

	Total group ($n = 14$)	Ambulators ($n = 9$)	Non-ambulators ($n = 5$)	Ambulators vs non-ambulators
Body fat (%)	23.1 (7.1)	22.3 (8.1)	25.0 (4.4)	$p = 0.60$
Peak VO_2 ($ml.kg^{-1}.min^{-1}$)	27.3 (7.4)	30.1 (6.2)	22.5 (7.5)	$p = 0.15$
Peak power ($w.kg\text{-}^{-1}$)	1.50 (0.46)	1.60 (0.43)	1.31 (0.49)	$p = 0.36$
Peak HR ($bts.min\text{-}^{-1}$)*	185 (18)	193 (5)	171 (25)	$p = 0.15$
% of predicted HR_{max}†	92 (8)	96 (3)	89 (11)	$p = 0.19$
Peak RER	1.06 (0.09)	1.06 (0.07)	1.08 (0.15)	$p = 1.00$
Borgscore	16 (2)	15 (2)	16 (3)	$p = 0.80$

* HR = heart rate in beats per minute; † maximal heart rate predicted from 220-age (leg cycling) or 210-age (arm cranking) RER = respiratory exchange ratio.

Body fat and fitness

Results on body fat and fitness are presented in Table II. Based on the cut-off points for obesity, four patients were classified as obese (2 ambulators and 2 non-ambulators). No significant difference was found in percentage BF or parameters of fitness between the subgroups ambulatory patients and non-ambulatory patients. There was also no significant difference in peak VO_2 between patients who had performed the cycle test and patients who had performed the arm crank test (28.9 (7.0) $ml.kg^{-1}.min^{-1}$ and 26.2 (8.0) $ml.kg^{-1}.min^{-1}$, respectively, $p = 0.76$).

Level of everyday physical activity and relationship with body fat and fitness. The duration of the day (expressed as percentage of the measurement day) that patients ($n = 14$) spent on dynamic activities (composite measure: walking, wheelchair-driving, cycling, general movement) was 6.5 (2.3)%, range 2.5–9.8%. The ambulators spent 7.3 (2.3)% of the day on dynamic activities, whereas this percentage in the non-ambulators was 5.2 (1.6) ($p = 0.08$).

A significant ($p = 0.01$) correlation coefficient of 0.65 was found between time spent on dynamic activities and fitness (Fig. 1). Within the patients who performed the arm crank test, the

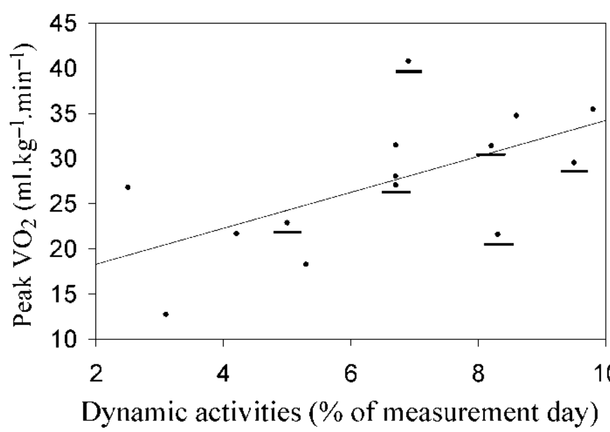

Fig. 1. Duration of the day (expressed as percentage of the measurement day) spent on dynamic activities (walking, wheelchair-driving, cycling, general (non-cyclic) movement) versus fitness (peak VO_2 in $ml.kg^{-1}.min^{-1}$) in 14 patients with meningomyelocele. Underlined dots are based on cycle ergometry. Spearman's correlation between time spent on dynamic activities and fitness was 0.65 ($p = 0.01$).

correlation coefficient between these parameters was 0.83 ($p = 0.011$), whereas there was no correlation within the cycle ergometry group. No correlation was found between the AM output parameter and body fat (or obesity). However, percentage BF was inversely correlated with fitness ($r_s - 0.58$, $p = 0.04$).

DISCUSSION

General

The study population was relatively small. However, we believe that the study population is representative for the MMC population and that the sample size is sufficient to provide insight in body fat and fitness of adolescents and young adults with MMC (primary aim). We also explored whether the level of everyday physical activity is related to body fat and fitness in this patient group. To our knowledge, relationships between the level of everyday physical activity on the one hand and body fat and fitness on the other hand have not been studied in the MMC population. Because we expect the ambulatory status to be an important determinant of body fat and fitness, the results for these parameters are presented as an average for the whole study population, and for the subgroups ambulatory patients and non-ambulatory patients. However, due to the relatively small sample size, conclusions about a lack of correlation between parameters and a lack of difference between subgroups are rather tentative.

According to Dutch reference data of healthy subjects (25), the patients of the present study were on average 10% shorter ($p = 0.002$) than expected for their age. In 9 patients height was less than the second percentile for age. This short stature has also been described by others (26–29).

Body fat

The prevalence of obesity (4 patients, 29%) as estimated in this study by the skinfold method is lower than found in other studies in MMC in which obesity occurs in about 50% of the patients (8, 11). This discrepancy may in part be explained by the different methods used to assess BF and obesity. However, the prevalence of obesity as found in the patients of this study is much higher than in non-handicapped Dutch children and adults (10%) (30, 31), indicating that patients with MMC are at risk for developing obesity.

Fitness

Based on the (peak) results on HR, HR as percentage of the predicted maximal HR, RER and the Borgscore (score of 16 corresponds with a perceived exertion of hard to very hard), it can be concluded that, despite peripheral limitations, the fitness tests reached almost maximal cardiorespiratory levels. Peak VO_2 in the patients who performed the cycle test was on average about 30% lower than reference values (19, 32, 33). Assuming that arm ergometry results in peak VO_2 values of about 70% of the peak values as measured during cycle ergometry (34), peak VO_2 in the patients who performed the arm crank test was about 20% lower than reference values (19, 32, 33). However, this comparison is not totally appropriate, as patients who are (partly) wheelchair-dependent are generally more used to performing work with the arms than healthy non-handicapped persons. Our finding of a distinctly subnormal fitness is in agreement with previous reports (12–14).

Relationship with level of everyday physical activity

In line with our expectations, patients with higher levels of everyday physical activity were fitter and patients with lower levels of everyday physical activity were less fit (Fig. 1). So, besides upper and lower extremity weakness, decreased venous return, and increased body fat, an inactive lifestyle may also (partly) explain the distinctly low fitness in MMC.

Because we used both cycle ergometry and arm crank ergometry to assess fitness, the relationship between level of everyday physical activity and fitness may be confounded by the use of different modes of exercise testing. However, this is not supported by the information in Fig. 1. Furthermore, fitness was not different between the arm crank group and the cycle group, and within the arm crank group ($n = 8$) there was also a significant correlation between level of everyday physical activity and fitness.

Because the study design was cross-sectional, no conclusions can be drawn on whether higher fitness levels result in a more active daily lifestyle or vice versa; there is probably an interaction between both parameters. We also expected a relationship between the level of everyday physical activity and body fat. However, although percentage BF was associated with fitness, no relationship with the level of everyday physical activity was found in this study. Possibly, the effect of age and gender may have confounded this relationship. Moreover, it should be realised that obesity may not only result from inactivity but may also originate directly from the disease itself (11).

CONCLUSION

An earlier study showed that adolescents and young adults with MMC (particularly the non-ambulators) are considerably hypoactive when compared with healthy peers (7). Based on the results of the present study, it can be concluded that both ambulatory and non-ambulatory adolescents and young adults with MMC are at risk for developing obesity and that their fitness is distinctly subnormal. The level of everyday physical activity seems to be related to fitness. The present and previous findings suggest that appropriate programmes (consisting of regular physical exercise, advice on physical activity pattern and dietary counselling) should be started early in the MMC population because they may prevent deterioration in body fat, physical fitness and daily functioning.

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