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# OVERWEIGHT AND OBESITY AND MOTOR PROFICIENCY OF 3- AND 4-YEAR OLD CHILDREN

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***ABSTRACT***

*Childhood obesity has increased over the last two decades, with increasing concern regarding health and other developmental risks. The aim of this study was to examine the prevalence of overweight and obesity and the differences in gross motor skills between overweight and obese 3- and 4-year old children and their non-obese counterparts in Potchefstroom. Three fundamental motor tasks were qualitatively (the quality of the execution of the skill) and quantitatively (the measurable score given to the performance of the skill, e.g. distance in mm) assessed in 19 overweight and obese participants and 111 non-obese participants in age-matched groups. The prevalence of obesity (15.83%) found in this sample, corresponds with worldwide and national trends in this age group, but is higher than the prevalence found in South Africa. Differences of statistical significance were established with t-tests as well as non-parametric analysis. The results showed no statistical differences in the 3-year old group, while statistical differences were found in favour of the non-obese participants in the 4-year old group with regard to quantitative scores for balancing on one leg and the quantitative and qualitative scores of catching, suggesting that overweight and obese children perform poor in comparison with non-obese children in tasks that require good balancing ability and good perceptual and spatial abilities. The results suggest that the influence of overweight and obesity on gross motor skill development is not significant at 3 years of age, but increases in such measurements that it can impede development at 4 years of age.*

**Key words:** Obesity; Motor competency; Gross motor skills; Pre-school children.

## INTRODUCTION

Childhood obesity has received a lot of attention in the literature in recent years (Goran *et al*., 1999; Owens *et al*., 1999; Van Mill *et al.,* 1999; Writer, 2000) due to the increase of obesity and overweight among children over the last two decades and due to the health risks involved (Van Mill *et al*., 1999; Dietz, 2000).

The prevalence of obesity has increased among American children over the last twenty years (Cheung, 1995) and an increase has also been reported among English and Scottish children aged 4 to 11 years (Chinn & Rona, 1994). Relatively little research has been done on the prevalence of childhood overweight and obesity among very young age groups in South Africa (Richardson, 1978; Monyeki *et al.*, 1999; National Food Consumption Survey, 2000). Richardson (1978) found a prevalence of overweight and obesity of 12-18% among white children, and 13-18% among black children aged 1-6 years, in his study on growth patterns in South Africa. In their study on the prevalence of obesity among pre-school black children in

Ellisras, a rural area in South Africa, Monyeki *et al*. (1999) found that boys of the ages 3-4 years showed the highest prevalence of obesity (15%). According to the National Food Consumption Survey of 1999 (National Food Consumption Survey, 2000), the average prevalence of overweight in South African children aged 1-9 years is currently 7.6%. However, the figure is much higher for children living in urban areas (12.5%), including 4-6 year old children (12%) (National Food Consumption Survey, 2000). The latter percentages are consistent with the prevalence of overweight among children in the United States of 11% to 24% (Flegal, 1999; Strand & Roesler, 1999; Ganley & Sherman, 2000) and in Canada (between 7 and 43%) (Marshall & Bouffard, 1997). Hernandez *et al*. (1998) found a prevalence of 32% in pre-schoolchildren, and these obese children showed significantly higher levels of blood pressure than their non-obese counterparts.

Other studies have also showed cardiovascular risk factors in obese children as young as three years (Freedman *et al*., 1999; Williams *et al*., 1998). Cardiovascular risk factors and other health risks associated with obesity in children including hypertension, diabetes, posture-related disorders and respiratory diseases, are emphasised in several studies (Raudsepp & Pääsuke, 1995; Auxter *et al*., 1997; Marshall & Bouffard, 1997; Neumark-Sztainer, 1999; Ganley & Sherman, 2000). However, relatively little research has been done on a different kind of health risk, possibly influencing the child's overall development and well being, associated with obesity, namely insufficient fundamental gross motor development of the pre-schoolchild.

The period of 2 to 7 years of age is considered to be the critical years of a child's motor development, as, through play and physical activities, the fundamental gross motor skills develop during this period (Gabbard, 1998; Gallahue & Ozmun, 1998). However, as obese children, especially girls, tend to avoid physical activity (Hoare & Larkin, 1991), this could lead to insufficient development of gross motor skills (Marshall & Bouffard, 1994; Auxter *et al.,* 1997). Obesity, social seclusion and the resulting poor gross motor skills could again influence total well-being as the child's self-confidence and self-esteem, thus emotional development is affected (Fox, 1992; Marshall & Bouffard, 1994).

Slaughter *et al*. (1980) found moderate correlations in body fat and horizontal jump, vertical jump and the 50m-dash in a study involving 7-12 year old children, whereas Raudsepp and Jürimäe (1996) reported a relationship between the percentage body fat, and standing long jump and shuttle run in a study involving 10-11 year old children. Hensley and Whitfield (1982) found inverted relationships between body fatness and performance in the standing long jump, vertical jump and 400m run in preadolescent children. In two studies involving 6 year and 9-year old boys and girls, Marshall and Bouffard (1994; 1997) found significant relationships between obesity and gross motor competency. Compared to the non-obese groups, the obese groups in this study showed significantly lower scores in the locomotor subscale of the Test of Gross Motor Development, consisting of tests for running, galloping, hopping, leaping, horizontal jumping, skipping and sliding. No significant difference was found in the Object Control Skills subscale, consisting of tests for two-hand striking, stationary bouncing, catching, kicking and overhand throwing.

No research could be found on the relationship between overweight and/or obesity and gross motor skills in 3- or 4-year old children. The question arising is whether the prevalence of obesity is similar to what was found in the National Food Consumption Survey (2000) and in

other countries and whether a relationship between overweight and obesity, and gross motor competency exists among children as young as 3 and 4 years of age, as no evidence exists of such a relationship in this age group in South Africa. The purpose of this study is therefore to investigate the prevalence of and possible relationship between overweight and obesity, and movement competency in a group of 3- and 4-year old children in Potchefstroom, a city in South Africa.

## METHODS

### Subjects

The sample consisted of a total of 120 white subjects, of the ages of 3 (n=54; 26 males, 28 females) and 4 (n=66; 32 males, 34 females) years respectively. Age was determined according to each subject's last birthday. All subjects lived in Potchefstroom, came from a middle class background and had been enrolled in the movement development programme (MDP) presented by movement developmentalists of the Potchefstroom University for Christian Higher Education (PU for CHE). This programme is being presented on the premises of 10 pre-primary schools in Potchefstroom, as well as at the movement development centre at the university. Nineteen (19) obese and overweight (O) subjects were identified from this group of 120 subjects. To classify a subject in the overweight or obese group, percentage body fat, BMI and the Marshall Visual Rating Scale (MVRS) of Marshall *et al.* (1990) were used.

### Research design

A one-time cross-sectional design was used as research method in the study. All the subjects were enrolled in the MDP for their first time, and all were evaluated before the implementation of the programme. All parents were briefed on the procedures before the evaluation started, after which informed consent was obtained from them for each subject. The evaluations were conducted on the premises of the schools and in the movement development centre at the university. Body composition measurements were done first, followed by the assessment of specific fundamental gross motor skills. The execution of these motor skills were videotaped and scored afterwards by the researcher.

### Body composition assessment

Skinfolds (triceps and subscapular) and body height and mass were measured according to the procedures outlined by Lohman (1992). Each skinfold was measured twice, and the average of the two measures taken. The sum of the two skinfold-scores was then used to determine the percentage body fat of each subject using the tables of Lohman (1992). The body mass index (BMI) of each subject was determined according to the formula of *BMI=body mass in kg/(body height in M)²*. As no national growth charts are available for the South African population, the growth charts of the Centres for Disease Control and Prevention (National Centre for Health Statistics, 2000) which are recommended for international use by the World Health Organization (Must *et al*., 1991) were used to classify a subject's BMI. To further confirm the diagnoses of obesity or overweight, each subject was visually evaluated using the Marshall Visual Rating Scale, MVRS (Marshall *et al.*, 1990). According to this simple rating test, "1" implies *slim* (thin, anorexic-like), "2" implies *ideal* (optimal weight to height), "3" *overweight* (plump but not indicative to a health risk), and "4" *obese* (grossly overweight, at

perceived health risk). To classify a subject in the overweight or obese group, a percentage body fat of 20% (males) and 25% (females) or higher and 25% (males) and 30% (females) or higher respectively (Lohman, 1992), a corresponding BMI on the 85$^{th}$ percentile or higher and the 95$^{th}$ percentile respectively, according to the growth charts of the Centres for Disease Control and Prevention (National Centre for Health Statistics, 2000) and a 3 or 4-rating on the Marshall Visual Rating Scale (Marshall *et al*., 1990) were used.

**Assessment of fundamental gross motor skills**

Hopping, one leg balance and catching were selected as the three gross motor skills to be tested, as these skills are used extensively in established, validated and reliability-proven motor test batteries for children of these age groups (Bruininks, 1978; Folio & Fewell, 1983; Ulrich, 1985; Frankenburg, 1990; Henderson & Sugden, 1992) and because they represent the three categories of movement, namely basic locomotion (hopping), static balance (one leg balance), and manipulation (catching) (Gallahue & Ozmun, 1998). These three gross motor skills were qualitatively (the quality of the execution of the skill) and quantitatively (the measurable score given to a skill, e.g. time in seconds) evaluated.

To obtain a qualitative score, the developmental characteristics of the performed skill were analysed and compared to the developmental stage criteria of the expanded version of the Fundamental Movement Pattern Assessment Instrument (FMPAI) (Gallahue, 1996) for fundamental motor skills in children of the ages 2-7 years. This system is based on the research of McClenaghan (1976), De Oreo (1980), Halverson and Williams (1985), and Cratty (1986) on the developmental sequences of fundamental movement skills in children. According to Gallahue (1996), the FMPAI has proven to be highly reliable among trained observers and content validity has been established for the fundamental movements. According to the criteria of this system (Gallahue, 1996), the performed skill can qualitatively be classified into one of the three stages of fundamental motor development, namely the initial stage, the elementary stage, and the mature stage. A score of (*1*) was awarded if the skill was classified as being in the initial stage of development, (*2*) if it was in the elementary stage, and (*3*) if it was classified as being in the mature stage. If the performed skill showed characteristics of both the initial and the elementary stages, a score of (*1.5*) was awarded, signifying the transitional stage between the initial and the elementary stage. The same applied to the transitional stage between the elementary and the mature stage, which was awarded a (*2.5*). The skills were quantitatively evaluated following the following procedures:

*Hopping* (Ulrich, 1985; Frankenburg, 1990): The test entailed two trials of hopping forward on one leg as many times as possible, up to a maximum of 12 hops. The higher score was taken. Hopping was tested on both legs.

*One leg balance* (Bruininks, 1978; Gustafson-Munro, 1985; Frankenburg, 1990; Henderson & Sugden, 1992): The test entailed two trials of balancing on one foot, with the arms hanging at the sides, for as long as possible up to a maximum of 12 seconds. The subject was instructed to stand with the free leg bent backwards at the knee so that the foot was positioned behind the standing leg. The bent leg had to be kept off the floor and away from the supporting leg. Swaying was allowed, and the arms were allowed to move from the sides. Balancing was tested on both legs.

*Catching* (Bruininks, 1978; Folio & Fewell, 1983; Ulrich, 1985; Henderson & Sugden, 1992): The test measured the ability to catch an aerial, underhand thrown 20cm ball with two hands. The thrower was positioned two meters from the subject. The score was the number of successful catches out of four throws.

Every test was conducted by the researcher, and every child was videotaped individually, from the side, by a trained assistant. The researcher then scored each subject's performance after analysing the video recording.

**Statistical analysis**

All calculations of means (*M*), standard deviations (*SD*), t-values, degrees of freedom (df) and p-values were done using the Statistica for Windows (6.0) computer programme (Statsoft, 1995). Due to the differences in group sizes between the O-groups and NO-groups in each age category, an additional non-parametric test (Mann-Whitney-U test) was administered to confirm the results of the independent t-tests.

## RESULTS

**Prevalence of overweight and obesity**

*TABLE 1.* **MEAN AGE AND BODY COMPOSITION VALUES FOR OVERWEIGHT OF OBESE (O) (n=19) AND NON-OBESE (NO) (n=101) CHILDREN**

| Age & Body composition measurement | 3-year olds | | 4-year olds | |
|---|---|---|---|---|
| | Obese (O) (n=9) | Non-obese (NO) (n=45) | Obese (O) (n=10) | Non-obese (NO) (n=56) |
| | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) |
| Age (year.month) | 3.05 ( 0.03) | 3.06 (0.03) | 4.04 (0.03) | 4.05 (0.03) |
| Triceps (mm) | 16.10 ( 3.46) | 9.65 (2.54) | 16.35 (1.11) | 9.55 (2.53) |
| Subscapular (mm) | 15.23 ( 8.65) | 6.87 (2.11) | 16.75 (8.15) | 7.24 (2.56) |
| % Body fat | 29.65 (10.02) | 15.99 (2.94) | 24.75 (4.25) | 15.63 (4.96) |
| Body height (m) | 0.99 ( 0.40) | 0.98 (0.49) | 1.09 (0.57) | 1.05 (0.59) |
| Body mass (kg) | 18.56 ( 2.07) | 15.32 (1.91) | 22.60 (4.88) | 18.11 (1.90) |
| BMI | 18.95 ( 1.97) | 15.98 (1.33) | 18.85 (2.45) | 16.30 (1.22) |
| MVRS | 3.69 ( 0.57) | 1.20 (0.12) | 3.54 (0.50) | 1.23 (0.37) |

SD: standard deviation

BMI: body mass index

MVRS: Marshall Visual Rating Scale score.

Nineteen overweight and obese subjects were identified, representing 15.83% of the total group. From this group of 19, 11 subjects (9.17%) were overweight and eight (6.67%) obese. Furthermore, nine overweight and obese subjects were identified in the 3-year old group representing 16.67% (9.25% overweight and 7.42% obese) of the 3-year olds, while 10 subjects were identified as overweight and obese in the 4-year old group, representing 15.15% (9.09% overweight and 6.06% obese) of the 4-year olds. The average body composition values of the O groups and the NO groups are presented in Table 1. The results of Table 3 show that differences of statistical significance were established for body mass, percentage body fat and BMI in both groups.

**Gross motor tests**

*TABLE 2.* **MEAN VALUES OF THE GROSS MOTOR TESTS FOR OBESE AND OVERWEIGHT (O) AND NON-OBESE (NO) CHILDREN**

| | 3-year olds | | 4-year olds | |
|---|---|---|---|---|
| | Obese (O) (n=9) | Non-obese (NO) (n=45) | Obese (O) (n=10) | Non-obese (NO) (n=56) |
| **Gross motor tests** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** | **Mean (SD)** |
| Hopping L quantitative | 2.22 (1.68) | 2.70 (1.76) | 4.60 (2.80) | 6.20 (2.81) |
| Hopping L qualitative | 1.11 (0.33) | 1.24 (0.43) | 1.50 (0.53) | 1.77 (0.50) |
| Hopping R quantitative | 2.38 (1.38) | 3.02 (2.10) | 4.50 (3.34) | 6.22 (3.01) |
| Hopping R qualitative | 1.13 (0.35) | 1.34 (0.48) | 1.50 (0.53) | 1.80 (0.43) |
| Balance L quantitative (sec) | 3.22 (1.86) | 3.23 (2.12) | 4.00 (1.41) | 6.25 (2.65) |
| Balance L qualitative (sec) | 1.44 (0.53) | 1.53 (0.50) | 1.60 (0.52) | 1.98 (0.53) |
| Balance R quantitative (sec) | 3.00 (2.00) | 3.18 (2.19) | 4.11 (1.62) | 6.09 (2.66) |
| Balance R qualitative (sec) | 1.38 (0.52) | 1.47 (0.55) | 1.78 (0.44) | 2.09 (0.55) |
| Catching quantitative | 3.44 (1.13) | 3.72 (0.81) | 3.30 (1.25) | 3.90 (0.37) |
| Catching qualitative | 1.33 (0.50) | 1.67 (0.52) | 1.60 (0.52) | 2.04 (0.38) |

1: initial phase
2: elementary phase
3: mature phase
1.5: transitional phase between initial and elementary phase
2.5: transitional phase between elementary and mature phase

The values in Table 2 indicate that differences favouring the NO-group were found in all the quantitative and qualitative evaluations of all three components in both the age groups. However, no significant differences were found between the O- and NO-groups for the 3-year olds with regard to any of the gross motor tests. In the case of the 4-year olds, significance ($p \leq 0.05$) differences were established for balancing on the left and the right leg (quantitative) and catching (quantitative and qualitative). As a significant difference in scores for hopping on the right leg (qualitative) and balancing on the left leg (qualitative) was established when applying the t-test, but not when applying the Mann-Whitney-U test (Table 3), these differences were not considered to be of statistical significance.

*TABLE 3.* **SIGNIFICANCE OF DIFFERENCES BETWEEN O- AND NO-GROUPS FOR 3- AND 4-YEAR OLD CHILDREN (N=120)**

| | 3-year olds (n=54) | | | | 4-year olds (n=66) | | | |
|---|---|---|---|---|---|---|---|---|
| | t-Test | | | Mann-Whitney-U | t-Test | | | Mann-Whitney-U |
| **Test item** | **t-Value** | **df** | **p** | **p** | **t-Value** | **df** | **p** | **p** |
| Body mass | -4.60 | 53 | 0.00* | 0.00* | -5.10 | 65 | 0.00* | 0.00* |
| % Body fat | -7.96 | 53 | 0.00* | 0.00* | -8.37 | 65 | 0.00* | 0.00* |
| BMI | -5.63 | 53 | 0.00* | 0.00* | -4.87 | 65 | 0.00* | 0.00* |
| Hopping L quantitative | 0.47 | 53 | 0.64 | 0.45 | 1.66 | 65 | 0.10 | 0.13 |
| Hopping L qualitative | 0.84 | 53 | 0.40 | 0.55 | 1.54 | 65 | 0.13 | 0.21 |
| Hopping R quantitative | 0.54 | 52 | 0.59 | 0.58 | 1.63 | 66 | 0.11 | 0.14 |
| Hopping R qualitative | 1.21 | 52 | 0.23 | 0.34 | 2.06 | 66 | 0.04* | 0.13 |
| One leg balance L quantitative | 0.00 | 52 | 1.00 | 0.76 | 2.61 | 66 | 0.01* | 0.01* |
| One leg balance L qualitative | 0.48 | 53 | 0.63 | 0.68 | 2.11 | 65 | 0.04* | 0.10 |
| One leg balance R quantitative | 0.21 | 53 | 0.83 | 0.85 | 2.16 | 65 | 0.03* | 0.04* |
| One leg balance R qualitative | 0.44 | 52 | 0.66 | 0.73 | 0.16 | 66 | 0.11 | 0.20 |
| Catching quantitative | 0.87 | 53 | 0.39 | 0.65 | 2.98 | 66 | 0.00* | 0.02* |
| Catching qualitative | 1.81 | 53 | 0.08 | 0.13 | 3.16 | 66 | 0.00* | 0.05* |

*= $p \leq 0.05$ BMI: Body Mass Index L: Left leg R: Right leg.

## DISCUSSION

The prevalence of 11 overweight (9.17%) and eight obese (6.67%) children found in this study, totalling 15.83% of the total group, is higher than the reported prevalence of overweight among pre-school urban children in South Africa, of 12% (National Food Consumption Survey, 2000). This percentage is also higher than or consistent with the estimated prevalence of obesity among pre-schoolchildren in the U.K. and Canada of 3% and 6% (Epstein & Higgins, 1992) and overweight among American children of 11-24% (Flegal, 1999; Ganley & Sherman, 2000). The age period of around 5-6 years is considered to be one of the periods of growth during which the risk for obesity is markedly increased (Goran *et al*., 1999). The high percentage of overweight and obese subjects in the age group in this study seems to support the suggestion of Bar-Or *et al*. (1988) and Goran *et al*. (1999), that an even earlier age period might be a period of high risk for the development of overweight or obesity.

No differences of statistical significance were found in the 3-year old group, suggesting that overweight and obesity do not influence gross motor skills at this early age. However, although not significant, all the scores of the NO-group in the gross motor tests were higher than the same scores of the O-group, indicating a tendency toward better gross motor performance of the NO-group. Possibly, because this group of children are at an early stage of gross motor development and vary considerably in their rate of motor development at this early age (Frankenburg, 1990; Gallahue & Ozmun, 1998; Thomas, 1999), differences in motor development are not yet significant.

No significant differences were established for hopping in the 4-year old group. Possibly, as in the case of the 3-year olds, the skill of hopping is at a too early stage of development at 4 years of age to be significantly influenced by overweight and obesity, although a tendency toward better performances in the NO-group can be seen (Table 2), which would be statistically significant at $p \leq 0.2$ (Table 3). Furthermore, relatively large standard deviations in these tests for hopping (Table 2) could be an indication that the rate of motor development at this age is too varied to show significant differences.

The results found with regard to the gross motor tests of the 4-year old group contradict the findings of Hensley *et al.* (1982) and Raudsepp and Jürimäe (1996), that adiposity is related to motor items in which the body is projected or moved, but not to static items such as one leg balancing and catching. However, their studies were based on results obtained on older subjects. Regarding balancing on one leg, significant differences were found in the 4 year old group regarding the quantitative scores of these tests (Table 3). This skill is dependent on good static balancing ability. The point of gravity shifts and the base of support (the feet) becomes smaller when a person's body size increases (Haywood, 1993). This factor can have a negative influence on performance in balance skills (Auxter *et al*., 1997). Furthermore, poor balance skills can be detrimental to the development of all other gross motor skills, as balance and posture control are the basis for the development of all gross motor skills (Auxter *et al*., 1997; Gallahue & Ozmun, 1998). The negative influence of obesity on this skill seems evident from these findings.

The significant differences in the quantitative and qualitative scores for catching which were established in the 4 year old group, indicates that the O-children in this group might already be lagging behind their NO-counterparts in their development of age-appropriate perceptual and

spatial abilities necessary to catch both accurately and skilfully. Possibly, the 4 year old overweight and obese subjects in this study, by avoiding or not participating regularly in physical activities, have not acquired the age-appropriate stage of development in these skills for which sufficient movement experiences are needed.

## CONCLUSION

To summarise, the results of this study show that there is a relatively high prevalence of overweight and obesity in this selected group of 3- and 4-year old children in Potchefstroom. They also show a relationship between important gross motor skills and overweight and obesity at the age of 4 years, and, although not significant, similar tendencies at 3 years of age. These results seem to suggest that the influence of overweight and obesity on gross motor skill development which may not be significant at 3 years of age, increases in such a way in one year's time that it may lead to gross motor deficits at 4 years of age. As these results lead to the question whether overweight and obesity could increasingly impede gross motor skill development as a pre-schoolchild gets older, further research is suggested to investigate the influence of overweight and obesity on gross motor skill development at 5 and 6 years of age.

The results obtained with this study should be evaluated in the light of the following limitations, lessening the measure of generalisability. Firstly, a comparatively small, and a selected, group of subjects was used. Secondly, the classification of overweight and obese children in one category might have influenced the results. It is possible that clearer differences might be obtained between groups if the classification of obesity (excluding overweight) is applied, thus comparing an obese group to a non-obese group. This may also limit the possibility of classification errors, which can be a problem at this young age due to large variation in tempo of growth. Bearing these limitations in mind, but also the significant differences found in this study, it is suggested that future research should be conducted to further examine the problem, but that they should make use of larger, and if possible randomly selected populations, and compare only obese groups with non-obese groups.

Overweight and obesity have many causes, among them caloric imbalance from eating incorrectly in relation to energy expended in the form of activity, dysfunction of the endocrine glands and emotional disturbance (Auxter *et al*., 1997). People working with pre-schoolchildren can contribute to the control or even prevention of overweight and obesity by creating an environment in which the pre-schoolchild is encouraged to be physically active and in which the child can have successful movement experiences, thus enhancing the child's feeling of self-worth (Hoare & Larkin, 1991; Auxter *et al*., 1997; Hernandez, 1998). One way of creating such an environment, is to optimise the development of gross motor skills in this critical period via sufficient and frequent physical activities. Acquisition of fundamental motor skills is essential to develop a healthy lifestyle and to participate in health-enhancing activities in later life, thus preventing obesity. Giving children of these young ages the stimulation and opportunities to develop these skills in order to develop a good self-image and a love for physical activity, could have a long-lasting effect on health behaviour and prevent the vicious cycle of a sedentary lifestyle, growing overweight, obesity and the concurrent health risks.

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