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HYPOKINESIS: INTERVENTIONAL ROPE SKIPPING MOVEMENT PROGRAMS FOR CHILDREN AND ADOLESCENTS

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SUMMARY

The downturn in children's interest in physical activity leads to a decrease in condition and the occurrence of civilization diseases, namely obesity and osteoporosis. The solution can be found in broadening the supply of physical education in schools and after-school physical activities that can children perform even on their own, without the necessity of high financial expenses. These activities should in long terms fulfil the parameters of suitable load, which will lead to positive changes in bone tissue density (Weeks, Young, & Beck, 2008) and enhancing the condition parameters (Sollerhed & Ejlertsson, 2008). Various applied intervention programmes have proven that in this point of view, the rope skipping seems to be a suitable application.

Key words: hypokinesis, bone tissue density, rope skipping, rope jumping, physical activity programmes, physical education at the grammar and high schools, bone mineral density

INTRODUCTION

As studies have shown, children are continuously losing the interest in physical activities and copying their parents' sedentary lifestyle. Mentioned lifestyle leads not only to the restriction of physical activities consequently connected with possible appearance of civilisation diseases, but also to a decrease in life's quality in older age. With admission to elementary school, children's amount of time spent by movement is steeply shortened. The impact of decline in physical strain is demonstrated in not only by obesity, but also in defective body posture and consecutive joint and muscle problems.

Doubrava (2002) mentions the necessity to reinstate proper exercising activity into a child's school day. He is reflecting to a study of Sport research Centre FTVS UK Praha. This study is called "School youth at the end of 20th century" and concerns the fitness capability of pupils of 6–14 years of age (Bunc et. al, 2001). The conclusions of the study are mentioning the decrease of time spent by movement with the age of child. Six-years-

old children spent four to six hours per week by physical activity, at the age of fourteen it's only two hours.

Physical education in schools in fact replaces what children should be performing independently and naturally. According to Havlíčková (2003) cannot "school P. E. substitute great lack of spontaneous physical activity of children in pre-school age". However, it's obvious, that quality programme of P. E. in schools can serve as a possible impulse for further physical activities of children. Chaille (2001) in her article stresses benefits of spontaneous activity – games during school breaks. Children, who have the access to outdoor playground, can choose the activity according their own interests and establish relationships to their classmates through a game. Children of younger school age prefer activities such as climbing, running, rope skipping, ball throwing etc., mostly in pairs or groups of three. The author understands the activity during school breaks not only as a possible time for social interaction among pupils, but also as a creative spending of free time, spontaneous choice of game etc. (Chaille, 2001).

The study of Sollerhed & Ejlertsson (2008) shows the lack of movement activities not only of children, but also of adults. They're analysing the possibilities of broadening the P. E. on elementary schools. They come out mainly from the conclusions of other authors (Reilly & Dorosty, 1999; Andresen et al., 2003; Kohn & Booth, 2003 in Sollerhed & Ejlertsson, 2008), who see the children obesity, resulting from the lack of spontaneous movement as a massive worldwide problem. Not only have the nutrition habits of children changed significantly-they are receiving much more energy mostly through consumption of sweetened soft drinks-but also the participation in everyday sporting activities has rapidly declined.

Authors Armstrong & Åstrand, 1997; Booth et al., 1997 in Sollerhed & Ejlertsson, 2008) are stating, that on one side, the children's interest to participate on free-time activities involving movement is decreasing, and on the other side the trend of shortening the time supply for P. E. on elementary schools was reported. In Sweden, the amount of P. E. lessons was shortened in 1990, providing more lessons for academic subjects. P. E. plays a significant role concerning the health of population and the prevention of civilisation diseases, the osteoporosis among them. Research, proving that the regular physical activity of desired volume can, to a certain extent, serve as the prevention of osteoporosis, has been realised.

The research of bone geometry of children was undertaken by authors (Ward, Roberts, Adams & Mughal, 2005). Total of 86 pre-pubescent children, 44 of them were top performing gymnasts (of an average age of 9 years, within interval of 5.4–11.9). This group was formed by elite sportsmen, who attend the gymnastics competitions regularly. The control group was formed by 42 children (age average 8.8 years, within interval of 5.6–11.9) from a regular elementary school in North-western England. Data were processed according to age, sex and height. At the beginning, the children were subjected to anthropometric measurements, which contained the determination of body mass using Seca digital scale. Furthermore, standing and seated height was measured using Leicester heightmeter. Pre-pubescent age of children was determined according to self-rating (with parents) according to Tanner typology. Average weekly physical and sedentary activity was recorded on the basis of previously confirmed questionnaires for determining average physical activity. Daily intake of calcium was adjusted according

to recommended dietary plans. For the evaluation of skeletal age, the x-ray images of non-dominant hand were acquired and rated according to Greulich Pyle method consequently. Bone densitometry was acquired on the basis of Periphery quantitative CT using Stratc XCT-2000. All measurements were carried out on the non-dominant side, measured in the area of forearm (in 4% and 50% of length), shin (carried out proximally to distal plain of methaphysis and 65% of total length of shin). Total trabecular volumetric mineral density of bones (hm/mm^3) and bone area of transversal cross-section (mm^2) were determined on 10mm cut in 4% length of tibis from proximal to distal end.

The Results of authors (Ward, Roberts, Young, & Mughal, 2005) showed, that gymnasts performed physical activities 14.8 ± 4.5 hours per week, compared to control group that spent by physical activities only 6.8 ± 3.5 hours per week. Conclusions report, that in the half of the radius, in total bone area, in peristoral circumference and cortical area were significantly higher values of SSI (skeletal stiffness index) for gymnasts than for the control group. No significant differences were reported for cortical BMD (bone mineral density). For the area of spine (L1–L4), BMC (Bone mineral content g), BMD (bone mineral density g/cm^2), BMAD (bone mineral apparent density g/cm^3) were higher for gymnasts in comparison to control group, bone area was insignificantly higher.

Frost (1990) defines the principles of lamellar bone adaptation originating form "mediator mechanisms", the so called drifts. These mechanisms affect the skeletal constitution, their shape, content and skeletal tissue distribution. During the formation of drifts, multinuclear osteoblasts are supplementing (on the basis of minerals resorption) new lamellas of the lamellar bone and during absorption; the drifts are removed, respectively (Enlow, 1963; Jee, 1988 in Frost, 1990). The process of drifts build-up that is maintaining macroscopic shape of bone is known as the minimodelation (Frost, 1988, 1989b in Frost, 1990). The process of bone modelling is most active in suckle and during continual maturing of skeleton tends to recede.

Mechanical stress of the bone leads to minor deformation or strain. Elastic skeletal intercellular bonds resist the strain by strength, the so called bone stress (Cochran,1982; Cowin, 1988; Currey, 1984; Kroc, 1984; Urist,1980 in Frost, 1990). The bone reacts on repeated effect of deformation force by increase in volume of bone tissue as well as the change of cross-sectional and longitudinal shapes (Burstein& Reilly, 1976; Cochran, 1982; Cowin, 1988; Currey, 1984; Reilly& Burstein, 1974 in Forst, 1990). However, deformation forces should exceed the limit ~ 1500 ± 30% μE (microstain) in pull and ~ 2500 ± 30% μE in pressure (Biewener & Tailor, 1986; Chin, 1988; Currey, 1984; Kroc, 1984; Lanyon, 1884; VPRS, 1980–1989, Rubin, 1984 in Frost, 1990).

Frost (1990 in Frost 1988) states six basic structural adaptations of lamellar bone, presenting independently or in combination skeletal adaptations on mechanical stress. Adaptations assume repeated and constantly increasing stress week after week until the start of adaptive bone modelling. Adaptation on these mechanical impulses: diaphysis gradually overloaded in compression, diaphysis gradually overload in bending plus a compression endload, trabecular gradually overloaded in compression or tension, trabecular gradually overloaded in compression plus bending and trabecular gradually overloaded in tension plus bending.

Physical Education of children and adolescence as the solution of Hypokinesis

According to Bunc (2006) is the movement intervention a form and volume of movement program aiming to influence certain part of physical fitness. Intervention programmes are aiming on cultivation and regeneration of one's organism and through this motivate the positive employment of a person in society. For the children of younger school age, such a programme does not only serve to motion dispositions development, but also to a training of elementary habits of healthy lifestyle. Movement programmes are also aiming to cultivation of movement expression as well as motivating the children to natural physical activity by attractive means. It concerns mostly accepting natural physical activity and also the automatizing of hygienic and safety habits.

Sollerhed & Ejlertsson (2008) see the solution of the problem in broadening the P. E. on elementary schools. The research proves that the amount of P. E. lessons should definitely be higher than given by ordinary curriculum. Inseparable part should be also the cooperation of parents on active life-style of their children. School cannot take over the responsibility for children life-style, but due to increasing number of physically inactive families, the role of the school in this context is increasing significantly and can be helpful (Armstrong & Åstrand, 1997 in Sollerhed & Ejlertsson, 2008).

The authors (Sollerhed & Ejlertsson, 2008) have undertaken research during 2000–2003. Extended lessons of P. E. were applied into ordinary curriculum at elementary school. Total of 132 children (73 boys, 59 girls) participated on the research. By the beginning of the study, the age interval was 6–9 years. The study was undertaken on two elementary schools, that were carefully selected and provided almost identical possibilities of and limitations for physical activities of children. On one of these schools, the N-school (N for normal), the P. E. was carried out regularly according to the curriculum, i.e. one lesson for children of 6–9 years, and two lessons for children of 10–12 years. Every lesson took 40 minutes. At the second school (I-school, with intervention programme applied), the P. E. was extended to a total amount of 4 lessons weekly (boys and girls separated, 40 minutes every lesson). On the fifth day, the children spent with teacher one hour outside.

This study of the authors Sollerhed & Ejlertsson (2008) has shown, that the children from school with intervention programme applied, evinced after three years improvement mainly in tests of persistence run, and tests of motoric abilities. These improvements were undoubtedly important for the self-confidence of children and can serve as a motivation for further physical activities (Harter, 1985 in Sollerhed & Ejlertsson, 2008). None such an improvement was observed in control school. P. E. in school should mostly aim towards fulfilling educational goals, but can simultaneously in long term horizon lead to positive motivation of children for the movement and play a significant role in propagation of physical activity.

Intervention rope skipping programmes

Rope skipping, the physical activity using ropes of various lengths has its application as a free time activity, fitness condition activity, curriculum of the P. E. in schools and a competitive sport. Systematic conception of rope skipping sport, which is supported by international rope skipping organization as well as the European organization, with its

system of competitions of individuals and teams, respecting unified competition rules, was established in 70's of the last century in U.S.A. Its founder is Richard Cendali, teacher of P. E. in the town of Boulder, Colorado (European Rope skipping Organization, 2004). In Czech Republic is this physical activity since 2005.

Rope skipping is extensively used during in sport preparation of children, youth and adults. Acquiring the technique of exercising with skipping rope has its effects for motoric control during jumps, speed of the motion of lower body limbs, dynamic force of lower body limbs, manipulation capability, dynamic balance and overall rhythmization.

A) Application of eight months intervention programme: In-school Jumping during P. E. lessons by means of rope skipping and its effect on skeletal tissue density.

Study of (Cassell et al., 1996 in Weeks et al., 2008) stresses the great potential during P. E. lessons mostly due to affecting the health and active attitude towards life. In later age, civilization diseases occur, caused by lack of movement, wrong life-style connected with stress and poor regime. One of the risks caused by the lack of movement in older age is also osteoporosis. Authors come up with possible solution to this problem and prevention by increased physical activity in childhood.

It appears that the intervention movement programmes, which are applied in childhood, lead to positive results by affecting the density of skeletal tissue and its increased resistance against mechanical stress. Children around seven years of age, that are regularly involved in physical activities and are consequently loading the skeletal apparatus, have significantly higher skeletal density than children with the lack of movement (Cassell et al., 1996 in Weeks et al., 2008). Medium and high intensity of exercising in childhood positively influences the skeletal density in hip bones and spine (Weeks et al., 2008). Wu et al., (1999) describes the differences in BMD of proximal part of femur of right and left lower limb of gymnasts (Rhythmic gymnastics, RG) in the context of different load on take-off and landing leg by means of detected reaction force, see. Fig. 1.

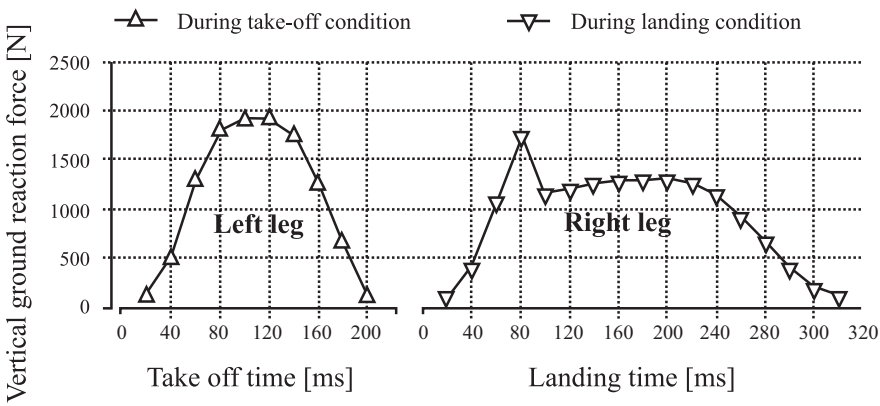

Figure 1. The course of vertical reaction force on the platform during take-off and landing for RG exercise on dynamometric pad. Edited by Wu et al. (1999)

The results of the study show, that the values of BMD for the left take-off limb are higher than for the right landing one, which is caused by higher maximum vertical reaction force during take-off than during landing.

Authors (Blimkie et al., 1996, Heinonen et al., 2000 in Weeks et al. 2008) present, that the time necessary for movement activity is minimum 10 minutes multiple times a week, to ensure the stimulation and positive effect on skeletal metabolism.

Studies show, that the mechanical properties of bones in later age are dependent on the acquisition of strength during first 20 years of life (Baliey et al., 1996; Bonjour et al., 1991; Slemenda et al., 1994 in Arnett & Lutz, 2002).

In publication Weeks et al. (2008), 46 adolescent boys and 53 girls took part on the eight-month intervention programme. The children were randomly divided into two groups (intervention and control group). Movement intervention consisted of 10 minutes exercise using jump rope. Intervention took place twice a week, at the beginning of exercising unit during school P. E. The content of exercise was chosen aiming to apply high impact load of skeletal apparatus with high volume, frequency and velocity. Ten minutes intervention contained approximately 300 rope jumps. Occasionally, the authors of the research included a strengthening exercise of upper body parts using exercising expand gum.

In a control group, normal exercising unit was carried out, beginning with warm-up and stretching exercise under the guidance of P. E. teacher. The exercise was chosen aiming towards the improvement of muscles flexibility and preparation of children for physical activities without specific load on skeletal apparatus.

Pupils were subjected to testing at the beginning and at the end of the investigated period. Anthropometric data concerning height, weight and BMI and level of maturity according to secondary sexual characteristics were recorded. Further, the test of lower limbs strength was carried out through vertical high jump. For the investigation of free-time physical activities a questionnaire was carried out to record the frequency of attending other physical activities during whole life in last 12 months.

The Authors of the research of intervention programme Weeks et al. (2008) are presenting following results. For girls, no significant difference was observed for height of vertical jump between intervention and control group. In authors' opinion, it was mostly due to the low motivation level. For boys, both in intervention and control group, a significant increase in vertical jump height was observed. No other differences were observed in either BMI or other movement levels for both intervention and control group.

However, eight-month movement programme caused positive result in increased concentration of bone minerals. For boys, significant improvement of skeletal density and its geometric parameters was recorded in the area of proximal part of thigh bone and lumbar spine. Further, significant changes were registered on the heel bone and the neck of femoral bone. Moreover, the decline in fat tissue of boys in intervention group was recorded. For girls in intervention group were observed changes in the neck of femoral bone and lumbar spine. These changes were also noted for the girls in control group, mostly in the area of lumbar spine. The authors rendered the difference between both groups of girls as non-significant.

The authors Weeks et al. (2008) based their theoretical premises for the realisation of the research on numerous results of other authors (Kannus et al, 1995; Blimkie et al., 1996; Heinonen et al., 2000; Witzke et al. 2000 in Weeks, 2008). These authors confirm

that the application of physical activities before reaching the pubescence brings greater benefit to a skeletal apparatus than the physical activity applied in post-pubescent age. Authors of other research confirm that the period of younger school-age is observed to be the optimal time for affecting the mineral density in bones (Bailey et al., 1996 in Pittenger et al., 2002).

B) Application of four-month rope skipping programme for high school girls.

The main aim of the research was to investigate the influence of rope skipping programme on the strength of heel bone (os calcis stiffness index – OCSI), secondly to determine, whether the values of the strength of heel bone measured by quantitative ultrasound technique (QUS) are dependent or independent on the values of mineral content in bones (BMC – bone mineral content). The values of BMC were diagnosed using the dual x-ray on the basis of DXA – dual x-ray absorptiometry. The interest of scientists (Arnett & Lutz, 2002) was aimed mainly towards the determination, whether the four-month rope skipping programme applied with various intensity on post-pubescent girls will result in increased the strength of heel bone measured using (QUS) see. Fig. 2.

Moreover, the scientists were interested, whether are the values of heel bone stiffness dependent or independent on the values measured for the area of lumbar spine and proximal part of thigh bone.

37 middle-school girls were subjected to this research. The students were randomly divided into two groups, the so-called high volume, and the so-called low volume. First

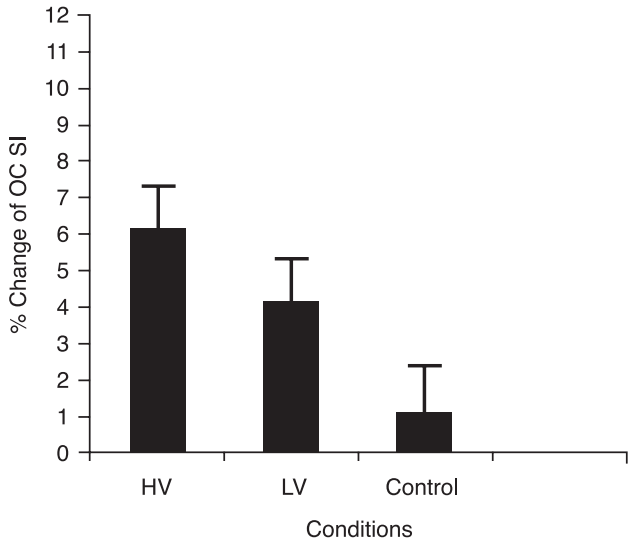

Figure 2. Percentual change ± SEM (standard error of means) of index of heel bone stiffness (OCSI – of the os calcis stiffness index) after application of movement intervention rope jumping for the period of four months, four times a week. According (Arnett & Lutz, 2002).
HV – high volume
LV – low volume

group was subjected to an applied rope skipping programme for 10 minutes, the other for 5 minutes, in both cases with frequency of 50 skips per minute, realized with close-leg jumps. The tempo of skips was directed by metronome. Averaged number of skips in 10 min. was 475 ± 88 and in 5 min. 258 ± 38. Intervention programme was applied four times a week at the beginning of exercising unit. The averaged reaction force of the platform during every skip was 3.2 ± 0.2 times the mass of the girl. Later on, after the setting of proper technique of rope skipping, girls in both intervention groups were equipped with load vests of 1kg. During the third and fourth month was the load increased to 2 and 3 kg, respectively (Arnett & Lutz, 2002).

The results of the research of authors (Arnett & Lutz, 2002) registered by post-pubescent girls in intervention group of high volume (10 minutes exercise), statistically significantly higher bone stiffness values than in the low volume group (5minutes of exercise). OSCI- the index of skeletal stiffness was increased by o 6.1% ± 1.3. Four-months intervention programme caused changes in all three investigated groups-in proximal part of femoral bone, in the part of lumbar spine and on large trochanter. These results reveal that if the high impact intensity by means of rope-skipping programme brought changes in the heel bone stiffness, then such a programme could be the solution to osteoporosis prevention.

C) Vertical reaction force of the platform of children during the realisation of rope skipping single-legged and both-legged.

The aim of the study (Pittenger et al., 2002) was to describe and compare the development of the reaction force of the platform during the rope skipping single-legged and both-legged. Rope skipping is considered to be a common and suitable activity for children of younger school age. The revelation of these principles can be useful for further application, partially for training of rope skipping activities during school P. E. lessons. By the cognition of the principles of this movement activity, the increase in bone mineral content can be achieved. The research was performed on 7 girls and 7 boys of the fifth grade in interval of 10–11 years of age. Each participant had at least 2 years' experience with rope skipping. Rope skipping was also the part of the schools P. E. curriculum during the realization of the research. The reaction force of the platform was measured on the force platform. Subjects were stockinged and their task was to realize imaginary rope skips single-legged and both-legged. The jumping rope was not used during the test to prevent the rope to affect the platform. The skips were performed with cadence of 84 jumps per minute. The data were recorded for the period of 10 minutes.

The results confirmed that the average value of the force peak was significantly higher for the single-legged jumps than for both-legged ones. The jump of the jumping rope single-legged differs significantly in the duration of flight phase and the length of the contact with the platform. The single-legged jump exhibited significantly shorter flight phase (118 ± 5 ms) and significantly shorter time of contact with the platform (566 ± 106 ms) compared to the both-legged (194 ± 5 a 491± 112 ms) for a flight phase and time of contact with the platform, respectively. The authors of this research Pittenger et al. (2002) are concluding the recommendation of further investigation of fatigue influence during realization of skips for a longer period. The authors mention, that by understanding the

fatigue's influence on the values of reaction force of the platform, we are going to be able create the movement programmes using rope skipping and prevent eventual risk of injury.

CONCLUSIONS

Recently, the fact, that the population of nowadays children does not seek the natural movement (i.e., they are lazy) needs to be embraced. In many cases, the parents cannot even motivate their children for a physical activity. This suppresses the influence of positive personal example. Children adapt the sedentary life-style of their parents and it becomes more comfortable for them. Upon consideration is also, whether the supply of physical activities provided by elementary schools is sufficiently attractive for children. The attractive supply of interesting, adventurous and original physical activities could attract and motivate children for movement.

As the most suitable appear those activities, that can be performed both in groups as well as individually. It's not exceptional that the children live in a long distance form school, which prevents them from natural meeting of their friends during afternoon hours and participating together with the group on leisure-time activities.

From this point of view, I consider the rope skipping activities as a possible solution to an activity supply, because this activity offers a possibility of cooperation in groups, pairs as well as individually. The child is not demotivated by the impossibility to perform the activity due to an insufficient number of participants. Physical activities using skipping ropes and broad variety of individual capabilities allow the participants progress individually and engage in different roles during the movement game. The skills can be ranked form the simplest ones, that are easy to perform even for pre-school children to those most complicated, that are enclosed by its nature and difficulty to the competitive sport. The participant can progress according to its current level of skill and fitness.

The intervention programmes of rope skipping offer the adequate mechanical stress of the skeletal apparatus of children and adolescence with positive result of skeletal indices as BMD, vBMD, BMC.

During adequate organization and stress time, the rope skipping activities appear to be suitable for effecting the fitness of children with possible transfer to later age resulting in increase of life's quality.

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HYPOKINEZE: INTERVENČNÍ ROPE SKIPPINGOVÉ POHYBOVÉ PROGRAMY PRO DĚTI A DOSPÍVAJÍCÍ

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SOUHRN

Klesající zájem dětí o pohybové aktivity vede k poklesu kondice a výskytu civilizačních chorob, ke kterým patří obezita a osteoporóza. Řešení lze nalézt v rozšíření nabídky školní tělesné výchovy a mimo školních pohybových aktivitách, které děti mohou vykonávat i samostatně bez vysokých finančních výdajů. Tyto aktivity by měly dlouhodobě splňovat parametry vhodného zatížení, které povede k pozitivním změnám hustoty kostní tkáně (Weeks, Young, & Beck, 2008) a zlepšení kondičních parametrů (Sollerhed & Ejlertsson, 2008). Řada aplikovaných intervenčních programů ukázala, že z tohoto hlediska se jeví jako vhodná aplikace rope skippingu (skákání přes švihadla) (Arnett & Lutz, 2002; Weeks, Young, & Beck, 2008).

Klíčová slova: hypokineze, hustota kostní tkáně, rope skipping, přeskoky přes švihadlo, pohybové programy, tělesná výchova na základních a středních školách

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