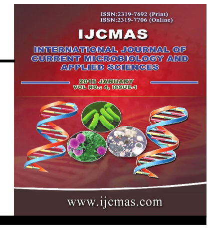

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Original Research Article

Muscle tendon elasticity efficiency of University athletes

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30 second endurance jump, Sit-up, Push-up, Lower back and hamstring flexibility

A B S T R A C T

This study examined physical and physiological elasticity of muscles in dynamic contraction and relaxation as well as range of motion levels of 129 university athletes to determine their musculoskeletal efficiency as required in day to day pursuit. The participants (69 males, 60 females), aged 15-36, had played for averagely 5.78±0.29years from who were in camp preparing for Ghana University Sports Association (GUSA) 2014 submitted themselves for measurement. Muscular autonomic reactivity over a period of time for contraction and relaxation in 30 SEJ, sit up, push up and LBHF were obtained and analysed with Friedman and Wald-Wolfowitz runs tests. There were statistically significant contraction in 30 endurance second jump [$\chi^2_{(14)} = 48.093$, p = 0.000, exact p = 0.000], push up [$\chi^2_{(52)} = 94.915$, p = 0.000, exact p = 0.000]; and LBHF [$\chi^2_{(36)} = 227.519$, p = 0.000, exact p = 0.000] based on Friedman test. Wolfowitz runs test showed that there were significance differences with regard to 30 SEJ (Z = -2.360, p = 0.018) and sit up (Z = -2.386, p = 0.017). The number of repetitive contraction and relaxation of muscles within the specified time indicates significant efficiency. The athletes in this study have fatigue resistance ability of musculoskeletal muscles needed for high and positive productivity level.

Introduction

Muscle tendon elasticity is defined as the natural ability of musculoskeletal system to return to its origin after contractions (Romanov, 2009). It is functional characteristic of individual in the pursuance of daily livelihood. Human activities could be driven largely through muscular efficiency of individuals (Alex de-Sherbinin *et al.*, 2007). Joyner and Coyle (2008) admitted the significant roles play by efficiency in long last musculoskeletal activity. Ability of athletes to work (labour) considerably in a given economic process depends to a large extent on function of musculoskeletal efficiency.

Oksbjerg and Therkildsen (2012) presented basic prenatal principles of muscle development in a form which shows that muscle tissue develops from the mesoderm and all events leading from mono-nucleated mesodermal cells to highly differentiated muscle fibres are called myogenesis (formation of muscle). Mesodermal cells are specified to become myoblasts (muscle cells), which proliferate several times. They align and eventually fuse forming multinucleated myotubes (a primitive muscle fibre), which express muscle-specific proteins (myosin, actin, troponin etc.). The effect of exercise on protein turnover in muscles depends on the kind of exercise and the type of muscle studied (Katch *et al.,* 2011). High-intensity resistance exercise training induces hypertrophy of the muscles involved in exercise by accumulation of myofibrillar proteins in the muscle fibres.

This accumulation has been associated with increased synthesis and either simultaneously increased or decreased degradation. With endurance training, the main change in the muscles is enhancement of the fatigue-resistance of the skeletal muscles, and only minor changes are seen in the muscle size (Oksbjerg and Therkildsen, 2012). Horowitz et al. (1994) published that the knowledge that exercise performance is greatly influenced by economy together with their observations that mechanical efficiency is related to muscle fiber composition of the exercising musculature, leads to the assumption that muscle fiber composition may directly influence exercise performance by improving mechanical efficiency.

Maintaining muscular contraction throughout lifespan is germane to maintaining health and preserving ability to perform normal life activities (Jeffrey, 2005) which could be transferred to productive lifestyle. Repetitiveness of muscular contractions in walking, running and jumping overtime improve flexion and extension at the joints (Kim, 2013). The extent of the range of motion at the joints of individual will determine the degree of work such individual can perform. During jumping, walking, and running, flexion of the body parts results in stretching of the muscles, like the vastus lateralis, gluteus maximus, and gastrocnemius and tendons (Kim, 2013) needed in economic activities. The efficiency of muscle contraction quantifies how much external work is obtained from the input of chemical energy (Jubrias, Vollestad, Gronka, and Kushmerick, 2008). External works of muscular efficiency in 30 second endurance jump (30 SEJ), sit up (per minute), push up (per minute) and lower back and hamstring flexibility are needed in daily activities. These are also utilised in the combination of pulling, pushing, lifting and even sitting in the place of work which should enhanced functional ability. Therefore, this study examined the muscle tendon elasticity complex efficiency [30 second endurance jump (30 SEJ), sit up (per minute), push up (per minute) and lower back and hamstring flexibility)] considering the number of repetitions executed within a specified time limit of university athletes on probable lively pursuance .

Materials and Methods

This was an observational study in which the measured muscular elasticity efficiency was compared with scholarly outputs and its implication on economic development inferred. One hundred and twenty nine athletes from nine games (mean age of 17.91 ± 0.475years, height of 1.61 ± 0.079m, weight of 66.19 ±12.75kg, body mass index (BMI) of 25.076 ± 4.42kg/m^2, blood pressure of 123.08/76.46mmHg, heart rate of 74.80bpm) participated in the study. The participants had a mean of five years of experience playing and signed consent form of the proposed study after secured approval of the Sports Directorate and coaching crew of the various games as well as went through trial sessions to minimize error during actual data collection. Each participant was randomly assigned a test order and assessed by one of the researchers. The core muscular elasticity tests performed were 30 second endurance jump (30 SEJ), sit up (per minute), push up (per minute) and lower back and hamstring flexibility. Age of the participants was recorded in years. PRESTIGE stadiometer (Model HM0016D, India) with weighing scale was used to measure height (m) and weight (kg).

Stethoscope and timer were used to measure heart rate while SICOA Ridge field N.J.07567 made in USA model of sphygmomanometer was used to measure blood pressure. Division of weight (kg) by the square of height (m) was recorded for BMI (Fryar *et al.,* 2012). Stopwatches and 30cm (12”) hurdle were used for 30 second jump. Hardford Count Sheriff protocol was employed for sit-up test. American College of Sports Medicine (2005a) protocols was followed to measure push up. Lower back and hamstring flexibility (LBHF**)** was measured using the Canadian Trunk Forward Flexion test box (Katch *et al.,* 2011; Pescatello, Arena, Riebe and Thompson, 2014). All assessment started after preliminary warm up sessions of the participants in their various games.

Measurement protocols

In this study, muscular elasticity efficiency was tested using 30 second endurance jump, sit up (per minute), push up (per minute) and lower back and hamstring flexibility.

The 30 second endurance jump assess agility and lower body strength endurance, three 30cm hurdle were placed on flat lawn. Competitively, participant by each hurdle started with both feet flat on the ground, perpendicular to the hurdle, jumped two footed over the hurdle to and from, continued for thirty seconds with the total number of jumps recorded.

Local muscular endurance is measured with sit up. Each of the participants assumed supine position on a gym mat with the low back flat, knees bent, heels flat on the floor and hands interlaced behind the head in the down position. In the up position, participants were asked to raise body until elbows crossed or touched the knees and returned until shoulder blades touched the ground for a complete repetition. One of the researchers who functioned as counter held down participant’s feet firmly ensuring hip remain on the floor without pulling the head with the hands. Participant could rest in the up position and discontinued when in the down position for more than three seconds. Incorrectly done sit up attracted correction but not counted and the total number of correct sit ups at the expiration of one minute or cannot continue was recorded.

Push up test is used to assess muscular endurance in the upper body. In the test, the standard down position using the toes as the pivotal point was utilised. The hands were shoulder width apart, back straight and head raise. The participant raises their body by straightening arms and then returns to the starting position, touching chin to the mat but not allowing stomach to touch the mat. With the back ensured to always be straight, push up was executed on a straight arm position. Maximum number of pushups performed accurately without rest until expiration of one minute or when the participant cannot maintain good form or strained forcibly or cannot continued were counted and recorded.

In the lower back and hamstring flexibility test, the participant's shoes removed, sat and made soles of the feet flat against sit and reach box at 26cm mark. Inner edges of the soles placed within 2cm of the measuring scale. Slowly reached forward with both hands as far as possible, holding the position for approximately two seconds. Researchers ensured that the participants kept hands parallel, do not lead with one hand, fingertips overlapped and in contact with the measuring portion of the sit and reach box. The better of two trials of the most distant point in centimeters reached with the fingertips was recorded.

Statistical Analysis

Data obtained were entered into MS excel 2007 and exported to SPSS Statistics 17.0 Data Editor where initial descriptive statistical methods were used. Thereafter, non-parametric statistics of Friedman test was applied to verify existence of normal distribution of the variables and Wald-Wolfowitz runs test was employed to determine significance difference among the groups using significance level of $p < 0.01$. Periodogram frequency analysis was presented to check for distributions of the contractions

Results and Discussion

The descriptive values of the muscle tendon elasticity efficiency variables are presented in table 1. Table 2 presents Friedman analysis on the significant of the variables as against table 3 with the result of Wolfowitz runs on the mean and median distributions of muscle tendon elasticity efficiency. Post hoc result using One-Sample Kolmogorov-Smirnov test analysis is presented in table 4.

The objective of this study is to examine 30 SEJ, sit up, push up and LBHF ability of university athletes; and look at the implication of efficiently executing these muscle-tendon elasticity skills on economic development. Results showed that mean contraction and relation of muscles during sit up and push up tests compared favourably with values reported by Golding (2000) and ACSM (2010). With regard to muscular contraction to execute LBHF, mean value obtained falls within poor and at risk region (less than 23cm) (YMCA; Amason *et al.*, 2004). We observed that scholarly work where 30 SEJ was measured is not available or scarce for effective comparison, though, obtained mean value is low. Our finding showed that participants have BMI of $25.076 \pm 4.42 kg/m^2$ which is the overweight category according to CDC. Competitive schedules of the athletes do not better their BMI which can negatively affect contractile efficiency of their muscles to pursue daily energy expenditures. Time series of muscular contraction in the execution of various muscle tendon contractions are shown in Figures 1–4. Mean and median distributions showed significant difference during 30 SEJ, sit up and LBHF execution muscular contractions.
These imply that the athletes though execute muscular contractions in various motions, but efficiency of those contractions overtime in dynamic endurance is limited. The chemical energy, adenosine triphosphate (ATP), to be converted into mechanical energy efficiency might compromise functional capacity. Irvine and Taylor (2009) asserted that muscle weakness and changes in skeletal muscle fibers are related to compromise because of peripheral neuropathy and reduced vascular supply. Barclay (1996) quoted from Goody and Holmes (1983) that the conversion ATP is performed by myosin cross bridges during

their cyclic interactions with actin filaments. Human body (irrespective of profession) generates ATP for muscle contraction by chemically converting food energy, using a process that ultimately requires oxygen (hence the need for a big oxygen delivery capacity), while minimizing the production of lactic acid that could deter effectiveness at work. Many activities (not limited to athletic performance) require skeletal muscles to contract repeatedly for sustained periods of time. Superior mechanical efficiency has potential to improve athletic performance (Horowitz *et al.*, 1994) because skeletal muscles are large reservoirs for glucose disposal in the body (Schuller and Linke, 2008) and physical activity stimulates glucose uptake through the action of the skeletal muscle transporter protein (Schuller and Linke, 2008).

During economic activities, chemical energy trapped within the ATP molecule is converted to mechanical energy via muscle contractions. Maximal oxygen consumption will however be limited by central cardiovascular function when the intensity and duration of activity at work increased, but also dependent on the peripheral adaptations that occur in the muscles of individuals who has experience due to long year of service in his profession. High efficiency creates the link between the physiological engine and the actual performance goal, to maximize average velocity. Barclay (1996) reiterated that muscle power output must take place from the cross bridge processes that generate force and filament sliding. The force dependent muscles cover multiple spinal segments, produced higher levels of force and coordinate multiple joints (Sharrock, Cropper, Mostad, Johnson and Malone, 2011). Sharrock et al. (2011) agreed that it is the combination of both muscle activation patterns that allows for control of the multi-segmented spine and the neuralising of forces.

The implications of the level of muscle tendon elasticity complex possessed by these sampled population on individual development are enormous. Most if not all professional activities involved in sustainable development require the combined effect of physical and physiological elasticity of muscular contractions e.g. engineering, agriculture, oil and gas, tourism, telecommunication. When a muscle contracts and shortens against a load, it performs work. Most often, some activities rely on transmission of impulse for innervations in cognitive functional capacity. The performance of work is fuelled by the expenditure of metabolic energy, more properly quantified as enthalpy (i.e., heat plus work) (Smith *et al.*, 2005).

Muscular energy availability, fibre types and nature of work are three main factors inherent in muscular contraction efficiency of an individual. ATP (output of systemic glucose) synthesis and utilisation are function of training as inversely proportionate to sedentary lifestyle. Muscle fibres (slow-twitch or fast-twitch) depend on ATP metabolic potential of individual and predisposed to greater success in both quick and prolong activities. Desirable perpetual exponential economic growth depends on energetic and environmental restrictions by the first two laws of thermodynamics (Kummel *et al.*, 2010). Kummel et al. (2010) opined that economics is only concerned with the behaviour of actors in the market superstructure where production process in the physical basis of industrial economy requires energy conversion devices needed by people, capital stock manipulated and supervised by people and machines of the capital stock activated by energy from people. These imply that economic activities are woven round the entity called 'Human Actions' that are activated through musculoskeletal contractions and range of motion permissible at the joints. Kummel, et al. (2010) reiterated that there are specific human contributions to production and growth that cannot be provided by any machine, even that a sophisticated computer is capable of learning from people. Ayres et al. (2013) added that when growth theory is expressed in terms of the linex loss function, without priori assumptions about output elasticity (determined economically) it turns out that the estimate of output growth is improved and that the primary drivers of growth are increasing supply of energy (primary energy input multiplied by the efficiency of conversion) and capital deepening in the economy.

In actual sense, efficiency in primary input in terms of physiological muscular contraction overtime can synthesis hormonal activation in body systems for higher economic growth. It can be expressed from the views of Ayres, van den Bergh et al. (2009) that a flow of energy (generated in the synthesis of ATP for physical-physiological muscular contraction), in some form, in just as essential for economic output (production) as capital. Muscoloskeletal fitness of African seen from the perspective of the sample (active individuals) in this study is normally distributed to spur economic development.

Human labour factor remains germane to productivity when neuromuscular stimulations are active and impulse transmitted consistently. When oxidative ATP is sufficiently available for muscular activities naturally, contractions and shortenings restrictions will be limited. Limitless muscle tendon elasticity scheduled for intermittent rest is poised for sustainable development.

Table.1 Summary of Muscle Tendon Elasticity Efficiency

Variables	**Mean**	**Std. Deviation**	**Percentiles**		
			25th	**50th (Median)**	**75th**
30 SEJ	9.364	3.574	7.500	10.000	12.000
Sit up	28.713	14.528	18.500	29.000	41.000
Push Up	31.317	17.861	18.000	30.000	42.000
LBHF	6.080	5.778	3.000	5.000	8.000

Table.2 Friedman Test Statistics Analysis

	30 SEJ	**Sit Up**	**Push Up**	**LBHF**
Chi-Square	48.093[a]	52.806[b]	94.915[c]	227.519[d]
Df	14	46	52	36
Asymp. Sig.	.000	.228	.000	.000
Exact Sig.	.000	.234	.000	.000
Point Probability	.000	.021	.000	.000

a. 0 cells (.0%) have expected frequencies less than 5. The minimum expected cell frequency is 8.6.

b. 47 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.7.

c. 53 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.4.

d. 37 cells (100.0%) have expected frequencies less than 5. The minimum expected cell frequency is 3.5.

Table.3 Wolfowitz runs tests Analysis

		30 SEJ	Sit Up	Push Up	LBHF
Test Value[a]		9.3643	28.7132	31.3178	6.0806
Total Cases		129	129	129	129
Number of Runs		52	52	56	54
Z		-2.360	-2.386	-1.546	-.736
Asymp. Sig. (2-tailed)		.018	.017	.122	.462
Monte Carlo Sig. (2-tailed)	Sig.	.020[b]	.020[b]	.126[b]	.467[b]
99% Confidence Interval	Lower Bound	.017	.017	.117	.455
	Upper Bound	.024	.024	.134	.480

a. Mean b. Based on 10000 sampled tables with starting seed 2000000

		30 SEJ	Sit Up	Push Up	LBHF
Test Value[a]		10.00	29.00	30.00	5.00
Total Cases		129	129	129	129
Number of Runs		52	52	56	54
Z		-2.360	-2.386	-1.325	-2.035
Asymp. Sig. (2-tailed)		.018	.017	.185	.042
Monte Carlo Sig. (2-tailed)	Sig.	.020[b]	.020[b]	.214[b]	.042[b]
99% Confidence Interval	Lower Bound	.017	.017	.203	.037
	Upper Bound	.024	.024	.224	.047

a. Median b. Based on 10000 sampled tables with starting seed 2000000.

Table.4 One-Sample Kolmogorov-Smirnov Test Analysis

	N=129	30 SEJ	Sit Up	Push Up	LBHF
Normal Parameters[a,,b]	Mean	9.364	28.713	31.317	6.080
	Std. Deviation	3.574	14.528	17.861	5.778
Most Extreme Differences	Absolute	.111	.095	.109	.180
	Positive	.062	.054	.109	.180
	Negative	-.111	-.095	-.054	-.116
Kolmogorov-Smirnov Z		1.256	1.080	1.237	2.044
Asymp. Sig. (2-tailed)		.085	.194	.094	.000

a. Test distribution is Normal. b. Calculated from data.

Figure.1 Periodogram of 30 SEJ by Frequency

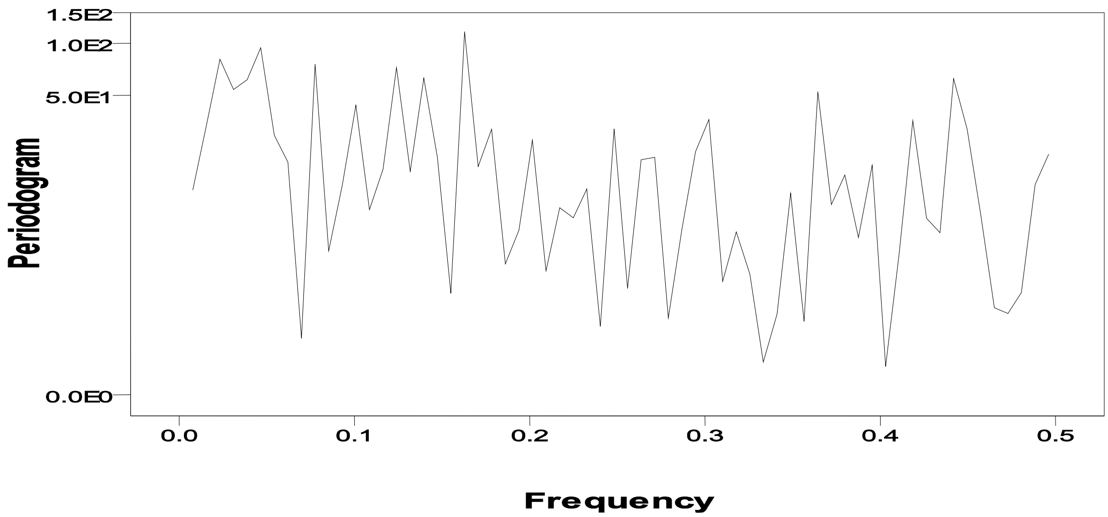


Figure.2 Periodogram of Sit up by Frequency

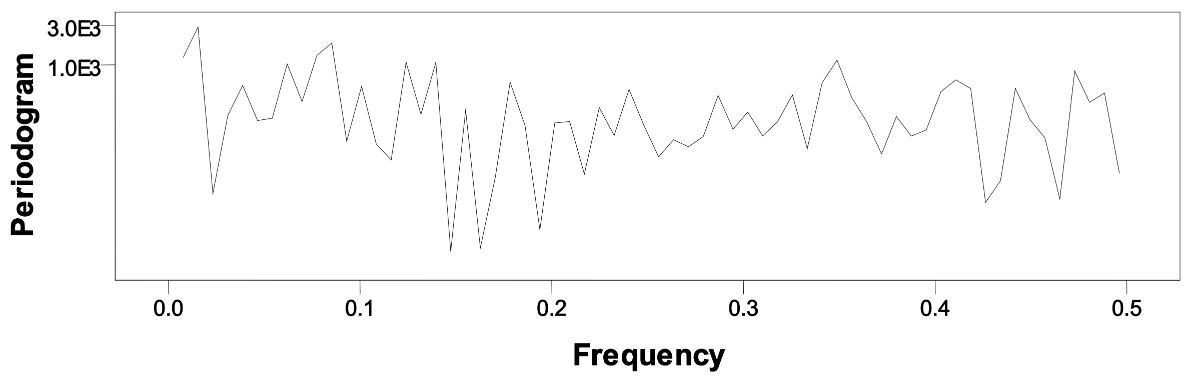


Figure.3 Periodogram of Push up by Frequency

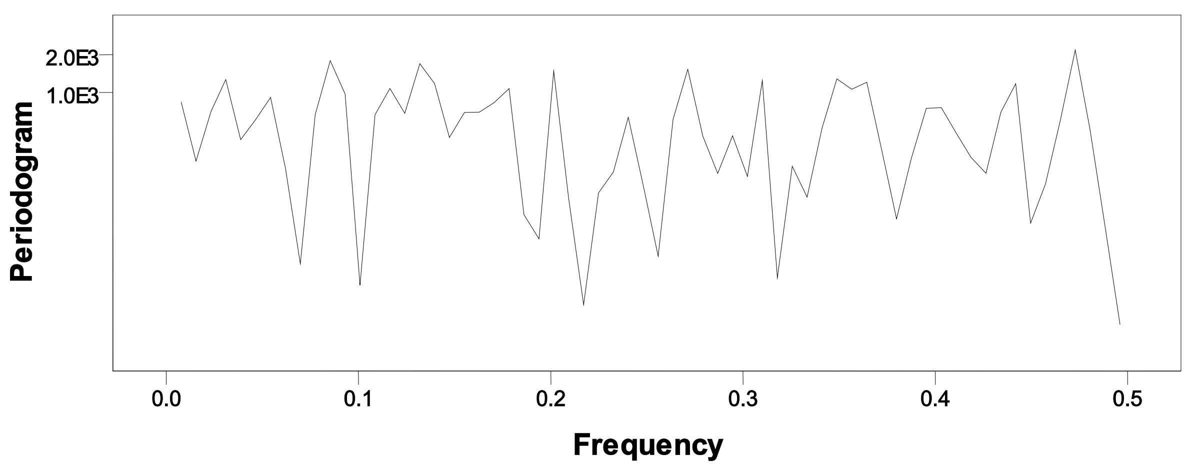
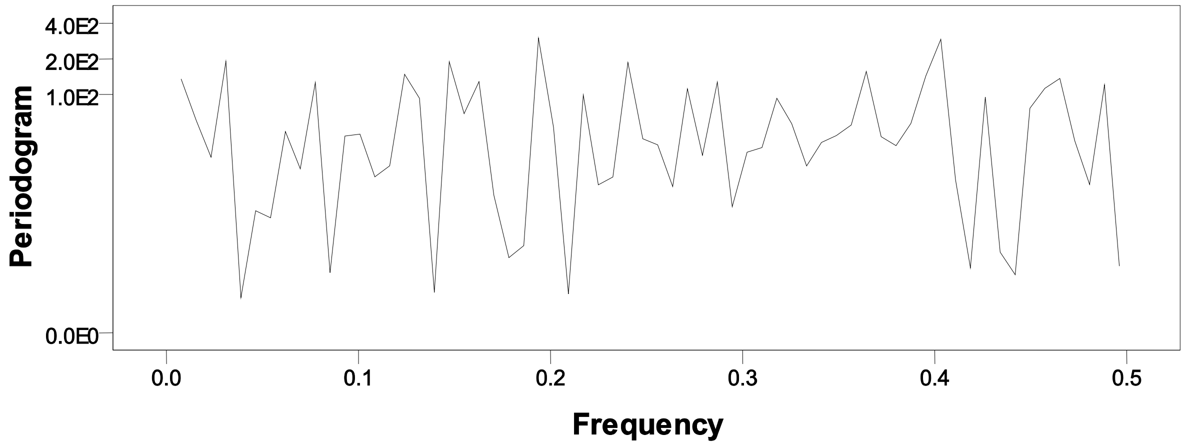


Figure.4 Periodogram of Flexibility by Frequency



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