

OBJECTIVE CRITERIA FOR DETERMINATION OF FUNCTIONAL-RESERVE POTENTIALS OF SECONDARY SCHOOL AGE PUPILS

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Abstract. *Purpose:* to substantiate criteria for determination of functional-reserve potentials of secondary school age pupils. *Material:* 1017 pupils of 5-9 forms from 16 schools were questioned. Besides, 200 physical culture teachers from 75 schools of 25 Ukrainian cities were questioned. 154 schoolchildren were tested/ Physical fitness and health levels were tested by index. Pupils fulfilled 4 simple test exercises. *Results:* we determined indicators of physical condition, psychic state, scopes of motor functioning. We substantiated criteria for determination of schoolchildren's functional-reserve potentials as well as values of boundary physical condition and physical fitness indicators, which guarantee strong health and optimal functional-reserve potentials of pupil's organism. *Conclusions:* Deviation of these indicators' complex from boundary values informs about pupils' potential belonging to group of risk. It requires correction of pupil's way of life and his (her) motor functioning.

Key words: pupils, fitness, physical condition, functional, reserve.

Introduction

Level of physical loads at physical culture lessons (PC) depends on pupil's functional-reserve potentials. Functional-reserve potentials are determined by medical workers, to whom a pupil was addressed by results of medical examination. At present, in Ukraine the main criterion for determination of pupil's health group is results of Ruffiet's test. But for persons younger than 17 years old this test is not informative. It is suitable for adults and does not consider natural increased heart beats rate of 6-16 years old children in rest state [8]. Its application results in mistaken addressing of healthy child to preparatory (PHG) and even to special health group (SHG) as well as in groundless decreasing of admissible physical loads at PC lessons. Scientifically adapted for children Ruffiet's test [8] is nearly unknown and is not used in practice.

Parents, if they wish, can fulfill adapted test in home conditions and determine independently workability of cardio-vascular system of their child. For this purpose they need certain skills and some equipment (stopwatch, metronome and so on).

Though for assessment of health and organism's functional-reserve potentials it is important to consider morphological, muscular, motor, cardio-respiratory and metabolic components [14]. While Ruffiet's test permits to assess workability of cardio-vascular system (indeed important but not the only in organism).

So we consider imperfect the existing criteria and means of determination of school age children's functional reserves: not informative, bulky, requiring special skills and equipment; not suitable for application in domestic conditions. That is why in practice individual level of optimal for every pupil load at PC lessons is determined by teacher, subjectively. Though, in conditions of integrated physical education (PE) of schoolchildren from different health groups it is important for teacher to have exact information about functional potentials of every pupil. For parents it would also be useful to know boundary indicators of physical condition (PCn) and physical fitness (PF) intrinsic to practically healthy children. Substantial deviation of indicators from boundaries of norm will permit to prognosticate probable worsening of health, to find "weak links" in functional state and take necessary measures in due time; for example to work out complex of exercises and choose methods of health strengthening.

Integrative PE of different health groups' children in Ukraine is accompanied by a number of unsolved problems, among which the most urgent (in opinion of PC teachers) is medical (91%) provisioning of this process. PC teachers' below average readiness for integrative lessons with different health groups' pupils also noticeably complicates this process. The existing criteria of pupils' distribution in health groups (by experts' assessments – 1.4, 1.6 points by 4 points' scale) also require perfection [1, 4, 13].

Pupils with health problems have some distinctions in a number of indicators of physical and mental condition, in PF [9, 10, 11, 19 et al.]. Local character of information about "corridors" of normal values of indicators of physical and mental condition, motor functioning (MF) and PF also hinder correct choosing of MF and PCn strategy. Deviations from their boundaries threaten with possible diseases and then passing to SHG.

Purpose, tasks of the work, material and methods

The purpose of the research is to substantiate criteria for determination of functional-reserve potentials of secondary school age pupils.

Tasks: 1. Determination of social-psychological indicators, PCn, PF, scopes of MF suitable for secondary school age pupils with different functional reserve potentials.

2. Determine objective indicators of PCn and PF, ensuring optimal level of pupil's functional-reserve potentials.

3. Find out optimal values of registered indicators.

Experiment was approved by ethic committee of university. Children's participation in experiment was confirmed by written agreement of their parents.

The methods of the research: generalization of literature data, questioning of schoolchildren, pedagogic: testing, experiment with application of tool methodic, medical biological methods, methods of mathematical statistic (determination of mean arithmetic and its standard deviation, regressive and correlation analysis).

Questioning of three health groups' children was conducted for determination of leisure kinds, which were of priority for them; preferable kinds of MF during lessons and out of lessons; different organizational forms of PE at schools; prevalence of harmful habits; their attitude to PC (their motive and interests: reasons of their negative attitude as well as missing of PC lessons) and passing tests for physical fitness. 1017 pupils of 5–9 forms from 16 schools participated in questioning. Among them there were 510 girls and 507 boys; 365 persons were from 5 forms; 342 – from 7 forms; 310 – from 9 forms. 631 pupils belonged to MHG, 327 – to PHG and 59 – to SHG.

The selected exercises were tested for authenticity. The testing witnessed that selected exercises had acceptable reliability ($r_{tt}=0,81-0,90$) and informative character ($r_r=0,80-0,89$) for assessment of physical skills in secondary school age.

For substantiation of logical (content) informative character we questioned PC teachers and experts in this field. 200 PC teachers from 75 schools of 22 Ukrainian cities were questioned. Experts ($n=19$) were 10 doctors of PE and sport sciences, 4 doctors of biological sciences, 5 candidates of PT and sport sciences, who worked in this field more than 20 years.

Tests' informative potential was determined empirically. As tests-criteria we used exercises with proved reliability. For this purpose we found correlation coefficient between results of passing of tests, constructed by us, and tests of previous testing.

For checking of tests for empiric reliability we involved 154 pupils of 5-9 forms (one form from every year). Initial testing we conducted in November – December. Main testing was conducted in January – February of the next calendar year. That is pupils had enough time for recreation of motor potentials. However this was insufficient for increasing of physical fitness. Conditions of testing, experimenters and contingent of the tested were the same in both cases. Main testing covered 1417 pupils of secondary school age школярів (10–16years old): 762 boys and 655girls.

Level of PF and health was determined by index, calculated with equation [2, 5] by results of passing of 4 simple test exercises: arms' bending and unbending (with arms behind back, resting on bench) during 20 seconds; throws and catching of volleyball ball with two hands from wall during 30 sec.; right (left) torso bents, mm; torso rising in sitting position during 30 seconds. Stating pedagogic experiment (for obtaining of regression equations) was conducted with application of tools' methodic. Correlation coefficient ($r=0,54$) between integral indicators of functional state of health and PCn and health of pupils witnesses that obtained by us equations of multiple regressions permit to assess pupils level of health with moderate accuracy.

Conditions of tests' fulfillment:

Arms' bending and unbending (with arms behind back, resting on bench) during 20 seconds. Only complete arms' bending and unbending were considered. The exercise permits to assess arms' power endurance.

Throws and catching of volleyball ball with two hands from wall during 30 sec. Distance from the wall was 2 meters. Hitting of ball was not considered – only catching with hands. Two attempts with rest paused of 2 minutes were fulfilled and the best result was registered. For complex assessment of different forms of dexterity we recommend to draw a "target" of 1x1 m on the wall with center at pupils' eye level (distance from floor to bottom of target shall be 1 meter. Throws out of target shall not be registered. It is recommended for assessment of pupils' dexterity.

Right (left) torso bents. Initial position – standing vertically, hands in contact with hips: level of distal phalanx of middle finger of hand on hip shall be marked with choke. A pupils bends to the right and stops in this position for 2-3 sec. Second choke mark is made. Then the distance between two marks is measured (accuracy of 1 mm). To avoid bending forward the exercise shall be fulfilled by the wall with pupil's shoulder blades being in contact with the wall.

It is recommended for determination of backbone flexibility in frontal plane and possible asymmetry.

We recommend calculating index of backbone mobility by the following formula:

$$IBM = \frac{(L_1 - L_2) \times 0,5 - (L_2 + L_1)}{L_3} \quad (1)$$

Where IBM – index of backbone mobility;

L_1 – (lower) result of one side bending, mm;

L_2 – (higher) result of other side bending, mm;

L_3 – length of body, cm.

Torso rising in sitting position during 30 seconds from lying position with legs bent in knees under angle of 90°; feet are fixed and arms are crossed on chest. It is recommended for testing of abdomen muscles' power endurance.

Diagnostic of pupils' functional state was carried out with the help of program apparatus complex "Omega-M", produced by Company "Scientific-research laboratories "Dinamika Technologies"" (S-t Petersburg) [15]. Integral indicator of functional state of pupils' health was deduced on the base of systemic analysis of functional and biological reserves, assessment of pupil's psycho-physical and psycho-emotional state. 85 pupils (42boys and 43 girls) were tested. The researches were conducted in conditions of ordinary working day in academic year (3rd academic semester), after standard warming up before main part of PC lesson. Electric cardiogram was recorded during 5 minutes in sitting position. Electrodes were applied on limbs according to commonly accepted methodic in 1st standard lead.

The levels of functional state were in the following ranges of indicators (conv.un.): 0,81–0,100 – функціональний стан організму відповідав нормі; 0,65–0,80 – normal functional state; 0,40–0,64 – insignificant deviations from normal state and repeated examination is recommended; 0,20–0,39 – functional state is far from normal – consultation with doctor is recommended; 0–0,19 – pre-morbid state, signs of pathological changes; clinical examination is recommended.

For measuring of MF scope we used Framingham method [7]. It implies timing of day MF and its assessment with energy equivalents of MF level. Person's day functioning was divided into five levels: basic, immobile, little, average and high. Certain kinds of functioning correspond to each of them. We accumulated and processed indicators of 857 pupils.

Medical-biological methods of the research were used for determination of PCn indicators. Measurements were conducted in compliance with commonly accepted methodic.

Ketle's index was received with formula:

$$IK = M / L, \quad (2)$$

Where IK – Kettle's index, g/cm;

M – body mass, g;

L – body length, cm.

Slouch index was obtained by formula:

$$SI = SA / SW \times 100, \quad (3)$$

Where SI – slouch index;

SA – shoulder arc (arc distance between shoulder points - back side, cm).

SW – shoulder width (distance between shoulder points - front side, cm).

Skibinskiy's index was determined by formula:

$$SkI = (VCL / 100) \times T / HBR, \quad (4)$$

where SkI – Skibinskiy's index

VCL – vital capacity of lungs, ml;

T – time of breathing pause after inhale, sec.;

HBR – heart beats rate in relative rest, b.p.m.

Index of pupils' somatic health was determined by express-method of G.L. Apanasenko. Our modification of this express-method implied usage of adapted by I.P. Zanevskiy (2013) method for assessment of cardio-vascular system's condition and physical workability of children and adolescents (see table 1).

Table 1. Gradation of levels of cardio-vascular system's functional reserve for secondary school age pupils (by [8])

Level of cardio-vascular system's functional-reserve potentials	Offered model, considering age						Health groups for physical culture lessons
	10 years	11 years	12 years	13 years	14 years	15 years	
1 – low	≥ 21,4	≥ 19,4	≥ 18,2	≥ 17,0	≥ 15,7	≥ 15,1	special
2 – below average	15,4-21,3	13,7-19,3	12,7-18,1	11,6-16,9	10,6-15,6	10,0-15,0	
3 – average	11,8-15,3	10,3-13,6	9,3-12,6	8,4-11,5	7,4-10,5	7,0-9,9	preparatory
4 – above average	8,2-11,7	6,9-10,2	6,0-9,2	5,2-8,3	4,3-7,3	3,9-6,9	main
5 – high	≤ 8,1	≤ 6,8	≤ 5,9	≤ 5,1	≤ 4,2	≤ 3,8	

Organization of the research: at first stage we found social-psychological, PCn, PF, MF indicators of secondary school age pupils with different functional reserve potentials (different health groups).

At second stage we accumulated objective (well known, simple in determination but, nevertheless, informative) indicators of PCn and PF, which ensure optimal level of pupil's functional reserve potentials. We considered informative such PCn indicators, which substantially ($p < 0,05-0,001$) differed in main and special health groups. By results of all 11 offered by us test exercises we observed confident distinctions between pupils of different health groups. Results of 4 test exercises, which are the most closely connected with integral indicator of pupils' functional state, also were considered to be informative.

At next stage we found optimal boundaries of the accumulated indicators. Pupils' indicators, which were characterized by high level of functional-reserve potentials, the best compensation reserves, high and above average organism's adaptation, sufficient activity and appropriate psycho-emotional state were considered to be optimal.

Results of the research

We determined social-psychological, PCn, PF indicators, scopes of MF for pupils with different functional-reserve potentials. Also we found that by great number of indicators distinctions of pupils from different health groups did not reach statistically confident significance. Their changes witness about existence of trend to changes of the mentioned indicators: in particular trend to worsening of pupils' attitude to MF (its different forms and means) with reduction of functional-reserve potentials.

We found indicators, by which secondary school age pupils with different functional-reserve potentials noticeably ($p < 0,05-0,001$) differ between each other. We determined that pupils with low and below average functional reserve potentials noticeably ($p < 0,05-0,001$) differ by a number of **social-psychological indicators**: they oftener watch TV; too rarely walk by foot and practice sports; have less sleep than representatives of other health groups. Among pupils with deviations in health there is bigger quantity of cigarette smokers and alcohol drinkers. Also they start smoking earlier that proves pupils' with health deviations bent to risky behavior as well as to devaluation of basic existential values, domination of biological demands (demand in stimulation with psycho-active substances). Their attitude to physical education is extremely less ($p < 0,05-0,001$) wish to pass tests for physical fitness and have differentiated mark on "Physical culture" discipline. Besides, they want to have less quantity of physical culture lessons in week [3, 6, 12].

We observed confident increase of quantity of pupils with low level of self-feeling and reduced functional-reserve potentials. Probably, it can be a result of weakening of their physical fitness. With increasing of deviations in health there appeared a trend to decreasing of subjective assessment of own functioning. It was proved by objective data about MF reduction with morbidity increase. Among DHG pupils there was confidently ($p < 0,05$) higher quantity of persons with weak nervous system than among physically stronger pupils [16].

Analysis of the received data witnesses that total volume of **MF** and **energy** consumption (see table 2) of pupils during day do not differ between different health groups. It can be connected with equally low level of MF

independently on functional-reserve potentials. Though, volume of high level MF in SHG is significantly less than in other groups. It should be noted that pupils with reduced functional-reserve potential one-night sleep 1 hour 45 minutes less ($p < 0,05-0,01$), than other. A little bit higher ($p > 0,05$) was undefined time of these children, which is a reserve for increasing of their MF.

Table 2. Motor functioning of pupils ($n=1017$) of different health groups різних

Indicators	Health groups	Special ($n=59$)	Preparatory ($n=327$)	Main ($n=631$)
Energy consumption, k.cal.		2006,69	2212,93	2238,96
		$\pm 513,54$	$\pm 490,56$	$\pm 498,80$
Motor functioning levels, %	high	0,52	0,67[^]	1,38[*]
	average	3,44	4,07	4,83
	low	33,34	34,77[^]	31,84
	immobile	12,93	13,22	13,73
	basic	31,45	38,10[*]	38,37^{**}
	undefined	18,31	9,17	9,85

Notes:

1. [^] – confidentiality of differences between indicators of 7th and 9th forms, PHG and MHG – $p < 0,05$;
2. Levels of differences' confidence: * – $p < 0,05$; ** – $p < 0,01$.

In *physical condition* confident ($p < 0,05-0,001$) distinctions between pupils with different functional-reserve potentials were registered by the following indicators: body mass, VCL; hand's power; a number of indices [slouch, resistance to hypoxia (Shtange), mass-height (Kettle), Skibinskiy]; index of somatic health; functional state and its components (organism's adaptation, vegetative and central regulation, psycho-emotional state). The most often we noticed distinctions in 13-14 years' age: in girls – oftener than in boys.

Analysis of integral indicator of *health functional state* of pupils (see table 3) resulted in determination that its level in MHG was above average. In PHG and SHG these indicators were lower (within "corridor" of mean values, characterized by insignificant deviations from norm. Though mean values of health condition in these both groups were assessed as satisfactory. Results of PHG were close to upper boundary of average level. SHG functional state indicators were close to lower boundary of average level. These indicators adjoined with abnormal values. So, pupils of different health groups demonstrated substantial ($p < 0,01-0,001$) distinctions in indicators and levels of their health functional state.

As it was expected pupils with reduced functional-reserve potentials confidently lagged behind their peers from other health groups by level of *all physical skills*.

The received results permitted to understand the borders of optimal values of chosen by us objective criteria for testing of pupils' functional-reserve potentials (see table 4). For determination of functional-reserve potentials' level it is necessary to compare PCn and PF (and MF) indicators with values, given in table 4. PCn and PF indicators in shown limits witness about high functional-reserve potentials of pupils. If there is substantial ($\pm \sigma$) deviation of one indicator or complex of them from boundary values, then scopes and intensity of pupil's MF require correction. It is necessary for prevention from possible worsening of health and pupil's potential belonging to SHG.

Discussion

In special literature there is quite a few data about distinctions of children's with different functional-reserve potentials indicators; in particular about distinctions between SHG and practically healthy children. The most often the object of scientific researches were children of certain age or of the whole period without differentiation by age. It made impossible to determine age dynamic of changes. In some scientific works there are results of examination of one sex children or only sick children of one nosology [9, 19]. It narrows the range of conclusions. There is nearly no data about specificities of leisure and place of children's motor functioning in it. Our data were received on sample of three health groups, of both sexes, of age groups 10-15 years old. These data are characterized by novelty, representative and informative character.

Table 3. Mean values of health functional state (conv.un.) of secondary school age pupils of different health groups

Health group	Indicators	Level of organism's adaptation	Indicator of vegetative regulation	Indicator of central regulation	Psycho-emotional state	Integral indicator of health condition
Main (MHG) (n=22)	M	0,75***phg	0,78 phg	0,70***phg	0,73*phg	0,74**phg
	S					AA
Preparatory (PHG) (n=45)	M	0,62***shg	0,65***shg	0,62***shg	0,64** shg	0,63***
	S	0,20	0,27	0,16	0,17	A
Special (SHG) (n=18)	M	0,43***mhg	0,39*** mhg	0,45*** mhg	0,48** mhg	0,44*** mhg
	S	0,24	0,26	0,20	0,20	A

Notes:

1. AA – above average, A – average level of health functional state.
2. Levels of distinctions' confidence: * – $p < 0,05$; ** – $p < 0,01$; *** – $p < 0,001$;
3. Little letters above wavy line denote groups of pupils between distinctions were registered.

Results of our researches supplement the data of other specialists [9, 10, 11, 19] about distinctions of children with deviations in health from healthy children. It was found that SHG pupils vary by a number of PCn, PF, MF indicators by psychic state from pupils with higher functional-reserve potentials. We confirmed that SHG pupils often have special social-psychological features. These features are characteristic for persons with health deviations: higher probability of harmful habits; increased demand in defense; separation from other children; increased anxiety; weakened self-assessment of own activity (proved by objective data). SHG pupils are group of increased risk of serious worsening of health owing to low level of some indicators. That is why they require increased attention of parents, pedagogues and medical workers. The found by us relatively less scopes of SHG pupils' day MF (probably) can result from low level of nervous cells' and nervous system in general workability.

Our researches confirmed [10, 11] the presence of confident distinctions between PCn indicators of secondary school age pupils. We confirmed that level of PHG pupils' lagging behind MHG pupils was less than between indicators of PHG and SHG. It was connected with less quantity and degree of confident differences. Application of progressive tool methods permitted for us to specify level of health functional state of SHG pupils (mean value is close to lower boundary of norm). It was confirmed [10] that condition of all physical skills of SHG pupils was substantially lower than indicators of practically healthy children. For the first time, for control during PC lessons we selected those exercises, results of which are connected with level of health functional state of pupils.

Our researches proved that high probability of high functional-reserve potentials of 10-12 years old girls is prognosticated by the following: high indicators of power index; higher than average indicators of modified Ruffiet's test; mean values of life index and Robinson's index. In case of boys they are high indicators of power index. They are higher than mean indicators of modified Ruffiet's test, life index and Robinson's index.

Such levels of PCn indicators ensure higher than average level of somatic health. Somatic health level by modified by us express-methodic of G.L. Apanasenko, considering modified Ruffiet's test, shall be above average (12,4±2,2 conv.un.).

Slouch index shall be higher than 95,43±4,22 conv.un. independent on age of a child.

Index of PF and health shall be within 0,54-0,57 conv.un. that characterizes its level as average.

Table 4. Optimal values of physical condition, physical fitness and motor functioning ($X \pm \sigma$) of 10-12 years old pupils with high adaptive-functional potentials

Indicators	Sex, age	girls			boys		
		10 years	11 years	12 years	10 years	11 years	12 years
Physical condition							
Kettle's index		257,18 $\pm 36,63$	255,64 $\pm 44,06$	316,31 $\pm 40,80$	249,26 $\pm 35,19$	258,11 $\pm 29,97$	267,05 $\pm 44,54$
Life index, ml/kg		54,93 $\pm 8,37$	61,58 $\pm 14,83$	53,19 $\pm 7,11$	70,61 $\pm 10,91$	70,84 $\pm 11,44$	69,91 $\pm 12,85$
Shtange's test, sec.		40,65 $\pm 9,49$	38,53 $\pm 8,17$	37,55 $\pm 9,61$	42,95 $\pm 5,14$	42,32 $\pm 7,34$	40,28 $\pm 9,48$
Skibinskiy's index		10,56 $\pm 4,36$	11,16 $\pm 3,68$	12,13 $\pm 3,47$	15,14 $\pm 3,84$	15,97 $\pm 4,87$	16,81 $\pm 6,86$
Power index, kg		59,45 $\pm 15,09$	59,04 $\pm 14,82$	58,22 $\pm 13,80$	78,40 $\pm 14,40$	74,47 $\pm 10,30$	75,57 $\pm 10,42$
Somatic health index (by modified express- methodic of G.L. Apanasenko), conv.un.		12,4 \pm 2,2					
Slouch index, conv.un.		95,43 \pm 4,22					
Physical fitness							
Arms' bending and unbending (with arms behind back, resting on bench) during 20 seconds, times		21,22 $\pm 3,75$	21,03 $\pm 4,47$	20,32 $\pm 7,83$	20,63 $\pm 5,02$	20,89 $\pm 5,90$	20,69 $\pm 6,15$
Throws and catching of volleyball ball with two hands from wall during 30 sec., times		25,94 $\pm 6,81$	25,39 $\pm 5,48$	27,91 $\pm 6,47$	27,21 $\pm 6,06$	28,03 $\pm 5,88$	32,52 $\pm 7,11$
Mean result of left (right) bent, mm		220,09 $\pm 45,46$	218,20 $\pm 42,62$	214,17 $\pm 46,99$	182,08 $\pm 53,49$	192,88 $\pm 50,07$	201,37 $\pm 47,89$
Torso rising in sitting position during 30 seconds, times		20,06 $\pm 5,53$	19,44 $\pm 5,46$	21,45 $\pm 8,33$	19,89 $\pm 4,90$	21,78 $\pm 5,81$	21,48 $\pm 6,28$
Index of backbone mobility, conv.un.		5,78 $\pm 1,62$	5,79 $\pm 1,81$	4,12 $\pm 0,99$	4,73 $\pm 1,89$	4,64 $\pm 1,45$	4,38 $\pm 1,27$
Index of physical fitness and health, conv.un.		0,54– 0,57					
Motor functioning							
Motor functioning of high level, % of day duration		$\geq 1,38$					

Notes: methodic of indicators' determination is given in the text.

Motor functioning of high level includes specially organized physical education trainings, sports' practicing, and participation in sport competitions, dances, and intensive games, run and hiking. It shall be of not less than 1,38% of day duration (2 hours and 20 minutes).

So, the offered by us method permits for physical culture teacher [parents or scientist with the help of not difficult measurements and PF tests (instead of medical tests)] to determine compliance with norm of functional-reserve potentials and degree of deviations in indicators. It guarantees sound health and optimal level of organism's functional-reserve potentials.

Conclusions:

We have determined indicators of physical conditions, psychic state, physical fitness, scope of motor functioning of secondary school age pupils. These indicators are interconnected with levels of pupils' functional-reserve potentials. We substantiated objective criteria for determination of pupils' functional-reserve potentials. We found values of boundary indicators of physical condition and physical fitness, which guarantee strong health and optimal level of pupils' functional-reserve potentials. Deviation of these indicators from boundary ones informs about potential belonging to group of risk. It requires correction of pupil's way of life and motor functioning.

The prospects of further researches imply working out of criteria for determination of functional potentials for senior school age pupils.

Conflict of interests

The authors declare that there is no conflict of interests.

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