Life Expectancy and Intensive Dynamic and Static Sport in the Area of Pre Heart Failure Treatment Therapies

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Abstract

Objectives: To determine the relationship between different levels of dynamic or static physical activity on life expectancy.

Design: Retrospective cohort study with passive follow-up and survival analysis for unidentified loss of follow-up.

Methods: Life expectancies of male Olympic medal winners (n=2,702) who died between 1950 and 1980 were analyzed for each decade. Athletes were subdivided into sport disciplines with low, middle, or high dynamic components based on the average percent of maximal oxygen uptake. Athletes were further subdivided into sport disciplines with low, middle, or high component of static exercise based on the level of maximal voluntary contraction.

Results: At all decades there was a significant lower life expectancy for athletes performing disciplines with high dynamic exercise independent from the amount of static exercise in different disciplines. In contrast, no such difference was found for disciplines with low or high static exercise. A life expectancy lowering was found for high static activity in athletes performing disciplines at the middle level of dynamic stress.

Conclusions: In elite athletes increasing the amount of dynamic aerobic exercise was correlated with shorter life-expectancies. It is tempting to speculate that high aerobic exercise causes cardiac stress at young age that interferes with age-dependent cardiac adaptations.

KEYWORDS: aerobic exercise; life expectancy; ageing; static exercise

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Introduction

In our days it is well accepted that an active life style or avoidance of a sedentary life style is healthy and lowers the risk of death for any reason, specifically for that of cardiovascular related death (Paffenbarger et al., 1986; Pekkanen et al., 1987; Powell et al., 1987). The interference between excessive physical activity, as it is performed by world class athletes, and life expectancy is however more difficult to predict. Several studies revealed differences among the various sport disciplines favoring specifically endurance sport (Sarna et al., 1993). Overall, a beneficial effect of high level sport on a general population could not be found at older ages (Schnohr 1971; Quinn et al., 1990).

Animal studies have been performed to address the question how physical activity affects the ageing process of the heart. In hypertensive rats exercise can worsen the adaptive remodeling process of the heart to pressure overload (da Costa Rebelo, 2012; Schultz et al., 2007). In such studies spontaneously hypertensive rats were used, a commonly used model of essential hypertension in which the animal develop spontaneously hypertension at the age of 6-8 weeks and survives quite well until the age of 12 months. It was recently shown that spontaneously hypertensive rats develop a more aggressive fibrosis in relationship to high aerobic exercise (da Costa Rebelo et al., 2012). Moreover, it was also found in the same model that the type of exercise modifies the molecular responsiveness of the animal. While swimming induced the expression of atrial natriuretic peptide and developed a regression of hypertrophy running activity did not produce such an effect (Endlich et al., 2011). It should be noted that all these molecular adaptations occurred in the presence of predicted and favorable adaptations, such as induction of nitric oxide synthesis and reduction of resting heart rate (da Costa Rebelo et al., 2012; Schlüter et al., 2011). Moreover, the detrimental effect of high physical performance could be avoided by administration of an angiotensin converting enzyme inhibitor, indicating participation of the renin-angiotensin-system in this process (da Costa Rebelo et al., 2012). Of note, positive effects of the inhibitor were already seen at levels not sufficient to reduce the blood pressure indicating that the effect is protective against age-dependent onset of heart failure rather than against hypertension.

The question arises whether similar adverse effects between high physical activity and mortality can be predicted for humans as well independent of hypertension. This requires a study in which different amounts of dynamic and static exercise is taken into consideration and in which treatments of heart failure are not interfering with the results. This can be analyzed by on the basis of historical data. To avoid regional differences the study should also be world wide as best. In order to address this topic the life expectancy of all Olympic medal winners was calculated who died between 1950 and 1980. Athletes were subdivided into groups with three different levels of dynamic or static stress according to previous suggestions (Mitchell et al., 2005). The analysis was performed by the difference in life expectancy between athletes from the different levels of dynamic and static components and subsequent Kaplan-Meier survival curves. Unlike previous studies on survival of former elite athletes this study is not aimed to compare the longevity of former elite athletes with that of a general population.

2. Methods

This study is based on an analysis of historical survival data that are available in public data base (see later). Therefore, this study does not require any Ethic Committee approval.

The study cohorts were male Olympic medal winners, who died between 1950 and 1980. A total of 2,623 male athletes were identified. Among them 79 male medal winners were identified who won medals in non-sport competitions (art disciplines). Data of the latter cohorts are given as a non-sport control group. When estimating life expectancies, those who died within the first 50 years (in most cases where it is known this is due to accidents) were excluded. Data were recorded from public data basis on Olympic competitors (http://de.wikipedia.org/wiki/Kategorie:Olympiasieger) and different manual registers of Olympic sport referred to in these public data basis as references. In total, complete data sets (birth day and day of death) could be found for 92.9% of all medal winners.

Sports were grouped according to the level of dynamic exercise and static exercise as defined before.[11] Briefly, dynamic exercise was sub-grouped in low, middle, and high values (A-C, respectively) according to the maximal oxygen uptake (max. O_2). Group A contained sport that normally accelerates MVO levels up to 40% max. O_2 and contained the disciplines golf, archery, diving, equestrian, bobsledding, luge, throwing, gymnastics, sailing, and weight lifting. Group B contained sport that accelerates max. O_2 levels between 40-70% and contained the disciplines fencing, volleyball, jumping, rugby, figure skating, running (sprint), downhill skating, and wrestling. Groups C contained sport with max O_2 levels upper than 70% and contained disciplines cross-country skiing, field hockey, running (long distance), soccer, tennis, basketball, ice hockey, running (middle distances), swimming, handball, boxing, canoeing, kayaking, cycling, decathlon, rowing, and speed skating. Static exercise was sub-grouped in low, middle, and high values (1-3, respectively) according to maximal voluntary contraction (MCV). Group 1 contained sport that requires up to 20% of MCV and contained disciplines golf, fencing, volleyball, cross-country skiing, field hockey, running (long distance), soccer, and tennis. Group 2 contained sport that required MCV between 20-50% and contained the disciplines archery, equestrian, jumping, figure skating, rugby, running (sprint), basketball, ice hockey, running (middle distance), swimming, and handball. Group 3 contained sport that normally ranged above 50% MCV and contained disciplines bobsledding, luge, throwing, gymnastics, sailing, weight lifting, downhill skiing, wrestling, boxing, canoeing, kayaking, cycling, decathlon, rowing, and speed skating.

The statistical analysis was done with statistical software SPSS 17.0. Comparisons between groups were performed by analysis of variance (ANOVA) and least significant difference as post hoc analysis. Levene's test was used to confirm normal distribution of the data. Survival curves were depicted using Kaplan-Meier analysis and a log-rank test was used to evaluate statistical significance between groups.

3. Results

The sizes of the different groups are presented in Table 1A. There are no major differences in the proportion of athletes in the different groups of dynamic or static exercise except a clear trend to a higher proportion of athletes in the group with the highest dynamic stress (Group C) during the last decades and a lower proportion in disciplines of group A. Table 1 also reports about the amount of events (= death for any reason) prior to the 50th birthday. These events were not included into the following analysis because they were mostly related to accidents. As shown in Table 1B there was no systematic bias in the subsequent analysis by eliminating these few events as they were regularly distributed in all groups under investigation.

Table 2 presents the mean life expectancy for the different groups in each decade. Of note, in all decades there was a significant lower life expectancy in the group with high dynamic stress (group C) in comparison to those with low dynamic stress (group A). Table 2 gives the mean differences between both groups including the 95% confidence intervals. Group B was mostly in the middle between both groups. In all decades the life expectancy of Olympic medal winners in art competitions (others) was highest or at the level of the highest group that is always the with the lowest dynamic exercise level. The corresponding Kaplan-Meier curves show the distribution between groups A-C at each decade (Fig. 1). The survival curves between groups A and C differed in all cases (log-rank test $p<0.05$; see Table 3). In contrast, no difference occurred between groups 1-3, challenging the effect of static stress on survival.

Table 2 also reports about a more detailed group analysis in which different sport disciplines are further subdivided in their relative proportion of dynamic stress on top of a given static stress. For groups 1 and 3 there was no effect of dynamic stress on top of the given static stress. However, in group 2 the level of dynamic stress lowered in mean life expectancy in each decade, significantly in the 50th and 80th. This is illustrated in Fig. 2.

In order to exclude other factors that may contribute to differences between groups it was also investigated whether the origin or age of entry into successful competition differs between groups. This was investigated for a representative cohort (decade 1980-1989). As shown in Table 4a, approximately 80% of all athletes came from Europe (no differences between groups A-C) and the data for the European athletes alone do not differ from overall analysis. Moreover, although life expectancy was lower in East-Europe compared to West-Europe a similar reduction in survival was found for both groups with increasing levels of dynamic exercise (Table 4b). Finally, athletes competing in disciplines of level C were significantly younger than those of level A and B as shown in Table 5. Finally we addressed the question how much athletes are still alive at the end of the observation period (1989) and whether this may bias the aforementioned analysis. This was however not the case. Among the 705 medal winners that participated in the 1928 Olympic winter and summer games, 76 (10.8%) were still alive at 01.01.1990. However, the percent survival was absolutely identical between the three categories of dynamic stress (A: 10.1%; B: 10.8%; C: 11.9%).

Another important question is whether the increasing professionalism during the last century including intensifying sport medicine and probably doping may have an impact on the outcome of our analysis. In general a proven impact of doping is low because doping tests were introduced in 1968 whereas the majority of all elite athletes included in this study participated at much earlier events. This is shown for the 1980-1989 cohort in greater detail (Table 6). The survival was lowest in the high aerobic stress group irrespectively whether they participated in Olympic Games between 1924 and 1964.

4. Discussion

Previous animal studies suggested a negative effect of high aerobic exercise on adverse cardiac remodeling leading to a reduced life expectancy at least on the basis of hypertension. However, the general interaction between excessive exercise of young adults and ageing in humans requires further analysis. We analyzed whether high physical activity interferes with life expectancy. In order to define a genuine effect of exercise on life expectancy it is important to analyze historical data that do not include cases of intensive today's standard therapy against heart failure. Therefore, studying historical data of world class athletes that were successful by former Olympic competitions and who died between 1950 and before 1989, in other words in the post war area but in the pre-treatment area of heart failure, are in ideal tool to address this question. Although no further variables could be included to this study, such as post-career behavior, cause of death, smoking, and blood pressure the study shows an inverse correlation between high dynamic activity and life expectancy that persists over a period of 40 years. No such correlation was found for disciplines with different levels of static component. The finding that the effect was highly reproducible in four different decades further supported the conclusion that high aerobic exercise seems to interfere with age-dependent mortality, and thereby primarily death for cardiovascular complication.

At first glance, the result of this study seems to be in apparent contrast to other studies that showed higher longevity and lower mortality in elite endurance athletes (Sarna et al., 1994), as reported for Finnish world class athletes (Teramoto and Bungum, 2010), Polish top athletes (Gajewski and Poznanska, 2008), tour de France cyclists (Sanchis-Gomar et al., 2011), and Olympic medalists (Clarke et al., 2012). In all these studies athletes developed a higher life expectancy compared to a general population. However, such comparisons revealed complete different results for various sport disciplines. Life expectancy was lower for American football players (Bourg, 1999) and sumo wrestling (Hoshi and Inaba, 1995) but neutral for others (Beaglehold and Stewart, 1983; Waterbor et al, 1988). The question whether the overall life expectancy between elite athletes and a general population differs, depends of course on the definition of the control group. Naturally, elite athletes have a low prevalence of genetic or chronic diseases but such prevalence contributes to the mortality of the general population. In the current study a strong comparison between elite athletes and a general population was therefore not performed. In this study, a non-athlete control cohort was only included by Olympic medal winners who won their medals in art disciplines such architecture or lyric. The overall longevity of this cohort was best or at least not significantly lower compared to the group having the lowest dynamic exercise. This cohort was also included in this study because disciplines that combine low dynamic and low static stress, such as golf, were not regularly performed during Olympics in the last century and therefore data of this group were lacking. However, the aim of this study was not to compare elite athletes with a general population, due to the difficulties described above, but to compare the effect of different extensities of sport to overall mortality. Furthermore, this study differs from the aforementioned studies because it did not analyze mortality beyond the 80ths of the 20ths century and therefore does not investigate the effect of modern heart failure therapy. Finally, we excluded all competitors that died within the first 50 years because the interaction between ageing and exercise should be analyzed. As outlined above, survival rates 30 years after competition do not analyze the same things and may therefore lead to different outcomes.

Of note, our control groups with low aerobic and static activity have a high level of socioeconomic background that may differ from the general population. There are also limitations in this study because such studies may combine age and cohort effects. It is reasonable to assume that athletes who are successful in disciplines with high dynamic components require an early start of intensive training that may affect cardiac remodeling in a different way if it would be performed later. This needs further attention in future studies and in particular well defined animal studies in which side effects can be excluded. In other words this analysis opens the question whether early intensive training at high aerobic exercise levels interferes already with the late phase of heart development during adolescence leading to interference with later occurring age-dependent remodeling processes.

The present study differs from previous similar studies as sport disciplines were compared on the basis of different levels of dynamic and static stress. Thus we include a dose-effect of aerobic and static exercise. Former studies simply analyzed aerobic versus power disciplines when comparing effects of different disciplines. This study also differs from previous studies because it does not analyze elite athletes from a small regional restricted area. Most of the athletes in the data base used here came from Europe (West and East) with North America as the origin of most of the other athletes. It is important to note that the relative amount of athletes from different origin does not differ between groups with significantly different life expectancies. Even more important, although life expectancy was different in West and East Europe, the effect of high dynamic exercise was seen in both subgroups.

Furthermore, life style will dramatically be changed between late 40ths and the 80ths. However, the main finding of this study was stable across all four decades making it unlikely that this will affect the outcome of this study. It will be of specific interest for future studies to analyze the data in subsequent years.

Due to the prediction from former animal studies it would be assumed that hypertension may be a relevant cofactor. Hypertension seems to be common even in athletes (O'Connor et al., 2007). Moreover, the effect of excessive exercise on blood pressure is more complex and includes vascular stress and oxidative stress (Bruno et al., 2011).

A strong comparison between overall mortality in the cohorts and death for either cardiovascular disease or other reasons could not be performed so far due to small numbers of published reasons for death. At least for German participants in Olympic Games a small number of athletes (n=22) could be identified to whom we know the reason for death. It was found that death for cardiovascular disease (myocardial infarction, myocarditis, stroke) had the highest prevalence (50%) followed by cancer (27.3%) and other diseases (22.7%). However, the small number of athletes does not allow a categorization to different disciplines as performed here, although there was a trend to higher prevalence of cardiac dependent death in athletes with higher dynamic disciplines (A: 33.3%; B: 50%; C: 60%). Thus, heart failure seems to contribute to the high amount of mortality found in elite athletes with high aerobic exercise.

In conclusion, high aerobic physical activity at young age negatively interferes with age-dependent processes in the heart reducing the maximal life-span in these persons. Therefore, we suggest that former elite athletes require a more extensive medical care than those with low cardiac stress in early adulthood.

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Table 1A: Characteristics of all participants

	N	Mean (y)	SD (y)	Median (y)	A %	B %	C %	1 %	2 %	3 %
1950-59	534	66.6	12.8	(69.0)	43.4	20.2	36.3	22.5	32.6	44.9
1960-69	750	70.8	13.0	(73.0)	41.1	20.9	38.0	21.6	28.9	49.5
1970-79	728	72.6	14.6	(75.5)	33.0	20.5	46.6	25.4	27.1	47.5
1980-89	611	73.7	14.2	(77.0)	24.7	19.8	55.6	23.1	30.2	46.6
Total	2,623									
Others										
1950-59	19	70.8	12.8	(74.0)						
1960-69	20	74.0	11.4	(74.5)						
1970-79	26	79.2	7.8	(80.5)						
1980-89	9	83.2	6.2	(83.0)						
Total	74									

Data represent the absolute number of participants in all cohorts and the relative proportion of them in the six different categories of sports

Table 1B: Event Rate before 50 years

	Total (n)	Events (n)	Events (%)	A (%)	B (%)	C (%)	1 (%)	2 (%)	3 (%)	Others (%)
1950-59	534	44	8.2	6.0	13.9	7.7	4.2	6.9	10.8	5.3
1960-69	750	47	6.3	2.6	10.8	7.7	4.3	6.0	5.9	5.0
1970-79	728	74	10.2	5.8	12.1	12.4	6.5	11.7	11.3	0.0
1980-89	611	43	7.0	4.6	8.3	7.6	7.0	9.0	5.7	0.0
Total	2623	208	7.9							

Data represent the absolute number of deaths before the 50th birthday (events) in all cohorts and the relative proportion of them in the six different categories of sports

Table 2: Mean life expectancies of medal winners subdivided into disciplines of different dynamic (A-C) or static (1-3) components

Table 2A) Died between 1950 – 1959

(above 50 years)

Others	n=18	72.6±10.8	(74.5)			
A	n=218	71.1±8.9	(71.0)			
B	n=93	70.2±8.4	(71.0)	-0.9	(-2.9 – +1.2)	p=0.419
C	n=179	67.3±8.1	(68.0)	-3.7	(-5.4 – -2.1)	p=0.008
1	n=115	68.9±8.2	(70.0)			
2	n=162	70.9±9.0	(71.0)	+2.0	(-0.1 – +4.1)	p=0.058
3	n=214	68.8±8.7	(69.0)	-0.1	(-2.1 – +1.9)	p=0.923
1A	n=2	79.0±6.2	(79.9)			
2A	n=71	74.4±8.9	(74.0)			
3A	n=145	69.4±8.4	(70.0)	-5.1	(-7.5 – -2.5)	p=0.000
1B	n=31	72.5±7.1	(72.0)			
2B	n=54	69.0±8.9	(70.0)	-3.5	(-7.1 – +0.2)	p=0.064
3B	n=18	66.9±7.2	(67.0)	-5.6	(-10.4 – -0.8)	p=0.024
1C	n=82	67.3±8.1	(69.0)			
2C	n=38	66.4±7.5	(66.0)	-0.9	(-4.1 – +2.4)	p=0.592
3C	n=50	68.3±9.3	(67.5)	+1.0	(-2.0 – +4.0)	p=0.500

Table 2B) Died between 1960 – 1969

(above 50 years)

Others	n=19	76.1±6.7	(75.0)			
A	n=300	74.4±9.0	(75.0)			
B	n=140	71.3±9.5	(71.0)	-3.0	(-5.0 – -1.1)	p=0.002
C	n=263	72.6±10.2	(74.0)	-1.7	(-3.3 – -0.2)	p=0.031
1	n=155	73.1±9.2	(73.0)			
2	n=204	73.2±10.6	(75.5)	-0.1	(-2.0 – +2.2)	p=0.934
3	n=307	72.5±10.0	(74.0)	-0.5	(-2.5 – +1.4)	p=0.572
1A	n=0	n.d.				
2A	n=79	76.6±8.9	(78.0)			
3A	n=221	73.5±8.9	(74.0)	-3.1	(-5.4 – -0.8)	p=0.008

1B	n=46	71.6±9.0	(72.0)			
2B	n=64	72.5±9.7	(73.5)	+0.8	(-2.8 – +4.5)	p=0.647
3B	n=30	68.4±9.5	(67.0)	-3.2	(-7.6 – +1.2)	p=0.153
1C	n=109	73.7±9.2	(75.0)			
2C	n=58	70.9±10.8	(72.5)	-2.8	(-6.1 – -0.4)	p=0.088
3C	n=96	72.4±10.8	(74.0)	-1.3	(-4.2 – +1.5)	p=0.346

Table 2C) Died between 1970-1979

(above 50 years)

Others	n=26	79.2±7.8	(80.5)			
A	n=226	79.5±8.6	(82.0)			
B	n=131	75.1±9.5	(76.0)	-4.4	(-6.4 – -2.3)	p=0.000
C	n=297	74.5±9.7	(75.0)	-5.0	(-7.3 – -3.9)	p=0.000
1	n=173	75.9±9.6	(76.0)			
2	n=174	74.6±9.5	(75.0)	-1.4	(-3.4 – +0.7)	p=0.185
3	n=307	77.6±9.5	(80.0)	+1.7	(-0.1 – +3.5)	p=0.063
1A	n=2	87.0±3.0	(87.0)			
2A	n=52	78.1±7.8	(78.5)			
3A	n=172	79.9±8.6	(82.0)	+1.8	(-0.9 – +4.4)	p=0.728
1B	n=39	76.3±11.5	(76.0)			
2B	n=57	75.5±7.7	(76.0)	-0.7	(-4.9 – +3.4)	p=0.720
3B	n=36	72.0±11.2	(73.0)	-4.2	(-8.8 – +0.4)	p=0.070
1C	n=132	75.6±8.9	(76.0)			
2C	n=65	70.9±10.2	(69.0)	-4.8	(-7.6 – -1.9)	p=0.001
3C	n=100	75.3±9.8	(75.0)	-0.3	(-2.8 – -2.1)	p=0.786

Table 2D) Died between 1980-1989

(above 50 years)

Others	n=9	83.2±6.2	(83.0)			
A	n=146	78.5±11.2	(81.0)			
B	n=112	77.1±10.4	(78.5)	-1.4	(-4.0 – +1.3)	p=0.313
C	n=310	75.0±10.6	(77.0)	-3.5	(-5.5 – -1.3)	p=0.002
1	n=114	75.6±11.2	(77.0)			
2	n=186	76.2±10.5	(78.0)	+0.6	(-2.0 – +3.1)	p=0.665

3	n=268	76.5±11.0	(77.5)	+0.9	(-1.5 – +3.3)	p=0.477
1A	n=0	n.d.				
2A	n=30	78.4±11.5	(81.0)			
3A	n=116	78.5±11.1	(81.0)	+0.1	(-4.4 – +4.6)	p=0.971
1B	n=23	80.2±9.7	(81.0)			
2B	n=50	78.3±9.8	(80.0)	-1.9	(-7.0 – +3.2)	p=0.466
3B	n=39	73.6±11.1	(74.0)	-6.6	(-11.9 – -1.3)	p=0.015
1C	n=91	74.5±11.3	(77.0)			
2C	n=106	74.6±10.4	(76.0)	+0.1	(-2.9 – +3.1)	p=0.956
3C	n=113	75.5±10.5	(77.0)	+1.0	(-2.0 – +4.0)	p=0.511

Data are means±SD and median in bracket. Mean differences from A, 1, 2A, 1B, or 1C, respectively, and 95% confidence intervals in brackets are also given. P values are calculated for groups with ANOVA p<0.05 on the basis of the least significant difference-test.

Table 3: Statistical analysis of the Kaplan-Meier curves

1950-59	Group A	0.156	(0.108 – 0.204)	
	Group C	0.078	(0.039 – 0.117)	p<0.05
1960-69	Group A	0.290	(0.285 – 0.295)	
	Group C	0.224	(0.174 – 0.274)	p<0.05
1970-79	Group A	0.522	(0.488 – 0.618)	
	Group C	0.238	(0.232 – 0.334)	p<0.05
1980-89	Group A	0.540	(0.432 – 0.596)	
	Group C	0.328	(0.276 – 0.380)	p<0.05

Data are survival rates based on the Kaplan-Meier analysis at the age of 80 years and the corresponding 95% confidence intervals.

Table 4: Distribution in Europe (1980-89)

Table 4a: Effect of increasing dynamic sport on life expectancy in Europe

(above 50 years)

		% of All	Age		MD(A)	95% CI	LSD
Others	n=8	88.9%	84.1±6.1	(84.0)			
A	n=123	84.2%	79.7±10.3	(81.0)			
B	n=83	76.8%	77.5±10.5	(79.5)	-2.2	(-5.2 – +0.8)	p=0.144
C	n=242	78.8%	74.6±11.1	(76.5)	-5.1	(-5.5 – -0.2)	p=0.036

Data are means±SD with median in bracket. Mean differences from A (MD(A)), and 95% confidence intervals in brackets are also given. P values are calculated with ANOVA p<0.05 and are calculated by least significant difference-test.

Table 4b: Effect of increasing dynamic sport on life expectancy in West- or East-Europe

West-Europe					East-Europe				
Level		% of All	Age		Level		% of All	Age	
A	n=102	82.9%	81.4±8.9	(82.0)	A	n=21	17.1%	71.4±12.4	(71.0)
B	n=68	81.9%	79.3±9.9	(81.0)	B	n=15	18.1%	70.1±9.5	(72.0)
C	n=207	85.5%	76.6±9.9*	(77.0)	C	n=35	14.5%	63.7±10.5*	(61.0)

Data are means±S.D. with median in bracket. P values are calculated with ANOVA p<0.05 and are calculated by least significant difference-test.

Table 5: Age of athletes when they won their first medal (data for 1980-89)

	Age (years)	MD (A)	95% CI	LSD
A	28.6±7.8			
B	26.6±5.3*	-2.0	(-3.4 – -0.6)	p=0.004
C	25.2±4.4*,#	-3.4	(-4.5 – -2.3)	p=0.000

Data are means±SD; *, p<0.05 vs. A; #, p<0.05 vs. B

Table 6: Life expectancy of athletes that died between 1980-89 in relationship to the Olympic Games at which they won their medals and the relationship to dynamic sport levels

Olympic Games	n	Level A	Level B	Level C	ANOVA
1912	32	91.5±3.2	99.0±0.0	93.5±3.6	n.d.
1920	126	86.8±5.3	86.4±3.3	87.1±4.1	p=0.868
1924	92	86.2±5.1	84.5±5.2	83.1±3.9	p=0.162
1928	124	82.1±5.2	81.3±5.0	80.0±4.2	p=0.265
1932	73	79.7±5.9	76.7±5.6	76.5±4.3	p=0.090
1936	102	77.7±5.3	76.1±5.9	73.8±5.7*	p=0.021
1948	53	69.6±5.5	66.7±5.6	65.5±7.1	p=0.228
1952	47	64.8±9.4	63.9±7.6	58.5±5.3*	p=0.033
1956	23	68.8±5.5	55.0±3.6	56.5±4.0*	p=0.000
1960	11	56.3±5.7	56.0±0.0	54.5±3.0	n.d.
1964	5	64.3±12.6	n.a.	51.5±0.5	n.d.
1968	1	72.0±0.0	n.a.	n.a.	n.d

Data are means±S.D.; Exact p values for ANOVA are given; *, indicates significant differences from level A.

Figure 1: Kaplan-Meier survival curve for athletes who died between 1950-59 (a), 1960-69 (b), 1970-79 (c), and 1980-89 (d). Data are given for groups A (max. O_2 uptake below 40%), B (max. O_2 uptake between 40-70%, and C (max. O_2 uptake above 70%). Log-rank test for A vs. C <0.05 in all figures.

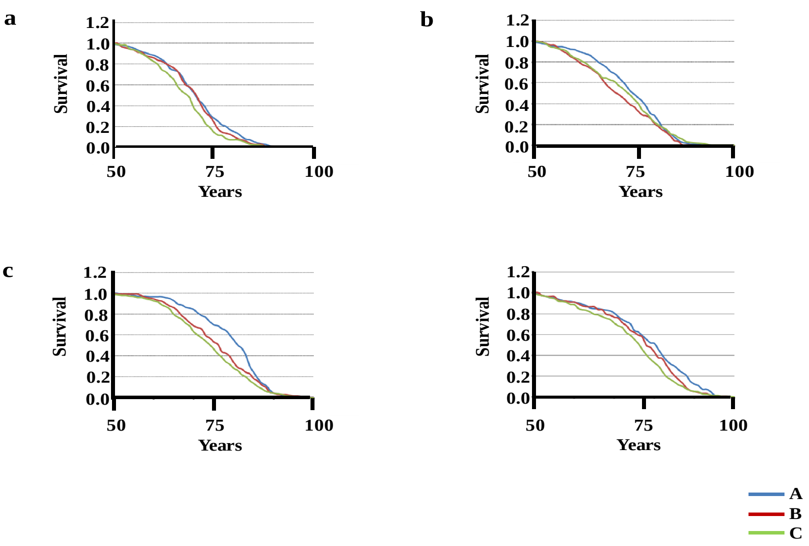

Fig. 1

Figure 2: Mean life expectancy for athletes competing in sport disciplines with max. O_2 uptake between 40-70% (Group B) and different amount of static component (groups 1-3, according to low static component (1; less than 20% MCV), middles component (2; 20-50% MCV) or high component (3; above 50% MCV). Data are means±SD. *, p<0.05 vs. group B1.

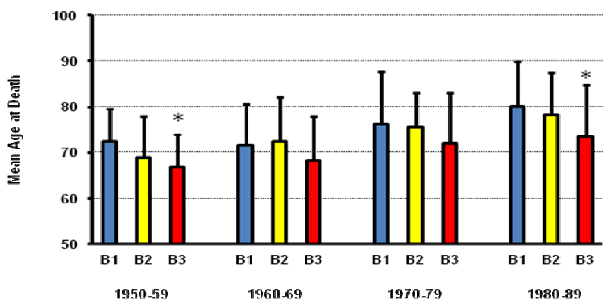

Fig. 2