ISSN : 0974 - 7435 Volume 10 Issue 13

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(13), 2014 [6915-6921]

Research on aerobics training to athlete limb joints and muscle force features influence

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ABSTRACT

Aerobics event is a kind of "forever young" and well-received sports event, so in recent years researches on aerobics aspects are also countless, the paper just on the basis of formers research, makes analysis and researches on body postures status when aerobics athletes take training to provide space analysis image base for researching its motion process knee joint force analysis; establish two rigid bodies two freedom degrees dynamical model to provide theoretical basis for motion process knee joint moment analysis; after that, the paper through applying table form, it more clear presents two aerobics athletes existing differences, by comparing,we can get that two aerobics athletes differences are relative obvious, so for No.1 aerobics athlete, he should control shoulder joint in 65° that is suitable, and in consumed time, it summarizes with difficulties increasing, two aerobics athletes differences will be more obvious, and meanwhile it reflects No.1 aerobics athlete ability is relative prominent, by elbow joint aspect comparing, we find that No.1 aerobics athlete ability is stronger than No. 2 aerobics athlete, so it proves No.1 aerobics athlete comprehensive strength is stronger. Finally by researching aerobics athletes body right knee minimum joint angle, it gets habitual posture and right knee minimum joint angle instant posture such two postures, when joint angle gets smaller, muscle strength moment will be bigger, and gravity moment will be bigger, and muscle strength moment will accordingly increase, the research will play certain roles in aerobics biomechanical analysis theoretical researches.

KEYWORDS

Aerobics athlete; Limb joints and muscle strength; Biomechanics; Physiological functions.

INTRODUCTION

Aerobics event belongs to non-Olympic Games events, aerobics development in China hasn't been accepted by people after going through a considerable long process, with people's living standards improvement, Chinese aerobics event are also entering into every civil mind, in the early period of the century, Chinese aerobics athletes participated in world aerobics championships, and achieved good result of ranking the seventh, and subsequent one year, in Chinese individual men competition,it got good result of ranking the top five, and in the process, Chinese aerobics have also gradually caught up with international pace, it let aerobics to gradually move towards maturity.

Regarding aerobics event research, many scholars and experts have carried out research, and meanwhile got abundant results, such as : Tan Yin-Yue in competitive aerobics event techniques analysis, took national aerobics men singles top eight athletes in 2005 as research objects to make research, the result showed that regarding jumping technical motion knee joint buffer range should be smaller than its supporting leg ankle joint buffer range, Chinese aerobics were to be improved in difficulty elements' air posture controlling, movement pattern control aspect, from which men were obviously weaker than women, so men aerobics athletes should more intensify in the aspect. But women aerobics athlete during taking-off of difficulty element, they weren't in place as men aerobics athletes; Liu Hao had ever targeted at year 1994to 2004,three years frames aerobics evaluation rules,he made resesarches,finally got that aerobics techniques changes from beautification to competitiveness were mainly evolved by rules, and put forward higher level requirements on perfection of routine.

The paper just on the basis of above researches, targeted at aerobics athletes limb joints and muscle strength, it makes systematic researches, by applying biomechanics and to other methods, it makes analysis to provide theoretical guidance for aerobics athletes better performing their technology.

BIOMECHANICAL ANALYSES OF AEROBICS ATHLETES LIMB JOINTS AND MUSCLE STRENGTH FEATURES

Research based on aerobics can divide it as a、b、c、d four kinds, from which the paper a kind totally includes Capoeira kind, Helicopter kind, Flair kind, cut kind, A-Frame kind, Plio push up kind, Wenson support kind, and push up kind. A-frame kind's series of motions totally contains seven kinds that are respectively explosive A-frame, explosive A-frame to Wenson, explosive A-frame twist to 1/2, explosive A-frame twist to 1/2 and then to Wenson, explosive A-frame twist to 1/2 and then raise legs to Wenson, I arm explosive A-frame, I arm explosive A-frame and then to Wenson, in the whole process, knee part movement is relative frequent, in the following it makes research on knee force problems.

Knee part mechanical analysis model when aerobics athletes train

Base on aerobics athletes biomechanics research, it can divide lower limbs force into low impact pace, high impact pace and non-impact pace three main kinds, from which low impact pace includes: marching type, touching step type, stepping forward type, one leg raising type; high impact pace: stepping forward and jumping type, two legs taking-off type, one leg taking-off type, back kicking and running type; non-impact pace. According to human body composition and attributes kinematics features, it can regard human body as rigid system model that is composed of 14 links, in the system, calculation the human body deducts right knee beneath joints weights can be regarded as total weight deducts right knee beneath two joints weights, and right knee beneath two joints weights total weight G can be got by formula (1) calculating:

$$G = mg \times \left(P_i + P_j\right) \quad \textbf{(1)}$$

In formula (1), m represents human body total mass, g represents local gravity accelerated speed, P_i, P_j are respectively right knee beneath two joints relative weights.

On the condition of human body balance, it can accord to mechanical conditions and force translation theorem, for aerobics training process knee force status, it makes analysis, as formula (2)shows relationships among muscle strength moment N_U, friction moment N_f, supporting moment N_n and gravity moment N_m that deducts right knee joint beneath joints.

$$N_U + N_f + N_n = N_m \quad \textbf{(2)}$$

The paper mainly researches human body knee joint force status in aerobics athletes training process, the parts that are correlated to knee joint is hip joint, thigh and shank, it can simplify human body lower limbs into plane two rigid bodies two freedom degree model, from which it gets involved in Hip,Thigh,Knee,Shank and ankle,apply Lagrange equation to establish constraint particle system dynamical equation, define Lagrange function L as difference between system dynamic energy K and potential energy P ,as following:

$$L = K - P \quad \textbf{(3)}$$

In above formula K, P can use any convenient coordinate system to express, system dynamic equation is as following formula shows :

$$F_i = \frac{d}{dt}\left(\frac{\partial L}{\partial \dot{q}_i} - \frac{\partial L}{\partial q_i}\right) \qquad i = 1,2,\cdots,n \tag{4}$$

In above formula, q_i is dynamic energy and potential energy coordinate, $\dot{q}_i$ is corresponding speed, F_i is the i coordinate acted force, thigh and shank joint variables are respectively using intersection angles α_1, α_2 to express,hip joint and knee joint corresponding moments respectively use N_h, N_k to express, thigh and shank masses are respectively using m_1, m_2 to express, thigh and shank lengths are respectively l_1, l_2, thigh and shank mass center position and joint center's distances are respectively p_1, p_2, therefore it is clear that thigh mass center coordinate (X_1, Y_1) is solving according to following formula, similarly shank mass center coordinate (X_2, Y_2) can also be solved by applying same methods:

$$\begin{cases} X_1 = p_1 \sin\alpha_1 \qquad Y_1 = p_1 \cos\varepsilon_1 \\ X_2 = l_1 \sin\alpha_1 + p_2 \sin(\alpha_1 + \alpha_2) \qquad Y_2 = -l_1 \cos\alpha_1 - p_2 \cos(\alpha_1 + \alpha_2) \end{cases} \tag{5}$$

System dynamic energy E_k and system potential energy E_p expressions are as following formula shows:

$$\begin{cases} E_k = E_{k1} + E_{k2}, E_{k1} = \frac{1}{2} m_1 p_1^2 \dot{\alpha}_1^2 \\ E_{k2} = \frac{1}{2} m_2 l_1^2 \dot{\alpha}_1^2 + \frac{1}{2} m_2 p_2^2 (\dot{\alpha}_1 + \dot{\alpha}_2)^2 + m_2 l_2 p_2 (\dot{\alpha}_1^2 + \dot{\alpha}_1 \dot{\alpha}_2) \cos\alpha_2 \\ E_p = E_{p1} + E_{p2}, E_{p1} = \frac{1}{2} m_1 g p_1 (1 - \cos\alpha_1) \\ E_{p2} = m_2 g p_2 [1 - \cos(\alpha_1 + \alpha_2)] + m_2 g l_1 (1 - \cos\varepsilon_1) \end{cases} \tag{6}$$

By above formula,it is clear that above formula showed Lagrange function expression,by formula (3) showed system dynamic equation,it can get hip joint and knee joint torques M_h and M_k as following formula shows:

$$\begin{bmatrix} M_h \\ M_k \end{bmatrix} = \begin{bmatrix} B_{11} & B_{12} \\ B_{21} & B_{22} \end{bmatrix} \begin{bmatrix} \ddot{\alpha}_1 \\ \ddot{\alpha}_2 \end{bmatrix} + \begin{bmatrix} B_{111} & B_{122} \\ B_{211} & B_{222} \end{bmatrix} \begin{bmatrix} \dot{\alpha}_1^2 \\ \dot{\alpha}_2^2 \end{bmatrix} + \begin{bmatrix} B_{112} & B_{121} \\ B_{212} & B_{221} \end{bmatrix} \begin{bmatrix} \dot{\alpha}_1 \dot{\alpha}_2 \\ \dot{\alpha}_2 \dot{\alpha}_1 \end{bmatrix} + \begin{bmatrix} B_1 \\ B_2 \end{bmatrix} \tag{7}$$

Among them, in above formula, B_{ijk} expression is as following formula shows:

$$\begin{bmatrix} B_{111} = 0 \quad B_{222} = 0 \quad B_{121} = 0 \quad B_{22} = m_2 p_2^2 \\ B_{11} = m_1 p_1^2 + m_2 p_2^2 + m_2 l_1^2 + 2 m_2 l_1 p_2 \cos\alpha_2 \\ B_1 = (m_1 p_1 + m_2 l_1) g \sin\alpha_1 + m_2 p_2 g \sin(\alpha_1 + \alpha_2) \\ B_{12} = m_2 p_2^2 + m_2 l_1 p_2 \cos\alpha_2 \quad B_{21} = m_2 p_2^2 + m_1 l_1 p_2 \cos\alpha_2 \\ B_{122} = -m_2 l_1 p_2 \sin\alpha_2 \quad B_{211} = m_2 l_1 p_2 \sin\alpha_2 \\ B_{112} = -2 m_2 l_1 p_2 \sin\alpha_2 \quad B_{212} = B_{122} + B_{211} \quad B_2 = m_2 p_2 g \sin(\alpha_1 + \alpha_2) \end{bmatrix} \tag{8}$$

Hip joint movement when aerobics athletes take training

When aerobics athletes take training, hip joint is a key joint that decides A-frame kind and others series of movements' completion, hip joint movement is whole body gravity center that decides height and balance functions, besides to clearly express, we use a to represent Wenson posture, then use b to represent explosive A-frame twist to 1/2 posture, use c to represent explosive A-frame to Wenson and then rotate to 1/2, use d to represent explosive A-frame posture, besides we also use an,bn,cn,dn to respectively express above four groups' left and right hip joints central point positions. When two aerobics athletes take training, hip joints Z axis positions' relative parameters are as following Table 1 show:

TABLE 1 : Two aerobics athletes hip joint parameters comparison (unit: mm)

Code No.	a Left	a Right	b Left	b Right	c Left	c Right	d Left	d Right	an	bn	cn	dn
1	1062.3	1052.1	944.6	1045.2	955.78	1014.2	956.7	977.4	1065.1	1029.8	1038.4	1015.9
2	950.65	964.15	884.15	978.15	884.14	896.25	907.2	948.75	987.47	958.25	958.25	968.25

By above TABLE 1, we can get: in above two aerobics athletes training, in explosive A-frame twist 1/2 to Wenson posture and explosive A-frame twist to 1/2 these two movements, No.1 aerobics athlete is best both in explosive A-frame to Wenson and explosive A-frame two movements' $3D$ coordinates and Z axis, and in two aerobics athletes training, regarding peak position hip joints comparative status is as TABLE 2 show:

TABLE 2 : Two aerobics athletes' hip joint parameters movement comparison

	No.1 aerobics athlete	No.2 aerobics athlete
	$\bar{x} \pm SD$	$\bar{x} \pm SD$
a Left	1061.124 ± 10.998	884.152 ± 26.145
a Right	1099.452 ± 4.258	964.152 ± 5.034
b Left	1052.014 ± 1.845	950.656 ± 7.145
b Right	1092.592 ± 18.987	978.154 ± 8.129
c Left	936.252 ± 6.124	907.263 ± 10.554
c Right	974.147 ± 2.048	896.256 ± 16.425
d Left	964.195 ± 26.789	884.147 ± 19.047
d Right	958.544 ± 6.481	948.753 ± 10.841
an	984.528 ± 22.967	958.256 ± 18.648
bn	1088.413 ± 18.642	958.256 ± 17.109
cn	1110.213 ± 6.458	987.473 ± 6.125
dn	968.223 ± 4.514	968.257 ± 5.314

By above TABLE 2, we know that when No.1 and No.2 aerobics athletes complete ab two groups of movements, there are no big differences between No.1 and No.2 aerobics athletes, which proves the two complete the two kind of movements have no difference; and cd two groups of movements exist obvious differences, in hip joint spring height aspect, No.1 athlete is far higher than No.2 athlete. When two aerobics athletes take training, peak hip joints comparison is as following TABLE 3 show:

TABLE 3 : Two aerobics athletes hip joint comparison.

Parameter	No.1 aerobics athlete	No.2 aerobics athlete
	$\bar{x} \pm SD$	$\bar{x} \pm SD$
a Left	1052.014 ± 1.845	1062.333 ± 1.852
a Right	1099.452 ± 4.257	1052.126 ± 20.450
b Left	1061.124 ± 10.998	944.64 ± 10.624
b Right	1092.592 ± 18.987	1045.124 ± 4.014
c Left	964.195 ± 26.789	955.785 ± 14.123
c Right	974.147 ± 2.048	1014.224 ± 11.33
d Left	936.252 ± 6.124	956.787 ± 2.451
d Right	958.544 ± 6.481	$977.475 \pm 18.26517.451$
an	1110.213 ± 6.458	1065.148 ± 11.561
bn	1088.413 ± 18.642	1029.852 ± 11.575
cn	984.528 ± 22.965	1038.451 ± 10.748
dn	968.223 ± 4.514	1015.974 ± 7.546

By above TABLE 3, we can see that in comparison between No.1 and No.2 athletes, there are obviously differences from previous table, two people have very big differences in coordinate position, and in hip joint peak, No.1 athlete is higher than No.2 athlete but it is not especially obvious.

Athlete joint angle analysis

Regarding athlete should joint angles research, it mainly starts and ends with push up, it is about main exertion phase in push up phase,it can play balance roles, but it cannot last to movement completion, so the phase mainly analyzes joint angles' features and makes comparison, starting parameters are as following TABLE 4 show:

TABLE 4 : Aerobics athletes' starting moment should joint angles coefficients

Code No.	a Left	a Right	b Left	b Right	c Left	c Right	d Left	d Right
1	82.12	78.05	79.40	76.27	78.56	76.11	78.12	74.64
2	69.14	65.12	63.10	66.47	62.45	62.66	63.52	56.78

Ending phase shoulder joint correlation parameters analysis TABLE 5:

TABLE 5 : Aerobics athletes' ending moment should joint angles coefficients

Code No.	a Left	a Right	b Left	b Right	c Left	c Right	d Left	d Right
1	76.00	82.10	82.60	56.82	76.12	75.84	86.96	54.06
2	75.12	74.23	61.70	67.80	49.55	52.86	54.23	58.54

By above TABLE 5, we can get in starting moment, No.1 and No.2 two athletes' shoulder angle are less than 70^0 ,and in ending moment No.2 shoulder angles are slightly big and No.2 left and right shoulder is not balance.

Elbow joint analysis

Elbow joint in general, it doesn't participate movement completion process as shoulder joint, but it participates in balance maintaining process, so carries out two athletes' comparison and analysis by following TABLE,as following TABLE 6 show:

TABLE 6 : Aerobics athletes' starting moment elbow joint angles coefficients

Code No.	a Left	a Right	b Left	b Right	c Left	c Right	d Left	d Right
1	68.40	66.25	70.21	63.25	68.20	61.92	66.23	62.05
2	71.23	68.22	72.78	68.84	75.84	66.89	77.23	66.78

In order to more vividly highlight two aerobics athletes' differences problems, the paper makes use of bar chart form more clearly presenting mutual differences and connections, after that make analysis of angles parameters in ending moment,its result is as following TABLE 7 show:

TABLE 7 : Aerobics athletes' ending moment elbow joint angles coefficients

Code No.	a Left	a Right	b Left	b Right	c Left	c Right	d Left	d Right
1	68.85	64.27	68.01	60.35	63.42	64.78	63.29	56.87
2	66.11	57.73	54.51	62.85	56.18	75.61	38.18	77.64

By above TABLE 7, we can get that in ending moment, No.2 aerobics athlete left elbow angle is quite small in b、d two groups, and No.1 aerobics athlete two directions' elbow joints angles are larger than that of No. 2 aerobics athlete, so No.1 should contract more elbow joint angle regarding A-frame kind in starting moment.

Quadriceps femoris analysis when aerobics athletes take training

During aerobics athletes training process, muscle is the main body that generates strength. When in standing position posture, human knee joint surrounding muscle maintains joint stability; it can guarantee human standing posture. It is well known that every individual standing posture has a certain difference so that make every individual muscle torque has also the difference. When aerobics athletes take training, they lie in the habitual posture, its right knee joint stability mainly relies on quadriceps femoris and ligament to maintain, and while knee joint makes flexion in habitual position, it will let quadriceps femoris excessive extension that prone to be fatigued, causing patellar ligament also prone to get injured.

In order to make research on knee joint muscle tolerable loading status when aerobics athletes take training, it get quadriceps femoris load bearing muscle strength values and their ratios with themselves own weight in habitual position posture as TABLE 8 shows.

TABLE 8 : Aerobics athletes' habitual position posture quadriceps femoris weight loading status

Aerobics athletes code No.	Quadriceps femoris muscle strength in aerobics athletes' habitual position posture	Aerobics athletes themselves weight	Weight bearing ratios
1	2093.72	558.60	3.75
2	2227.50	697.76	3.19
3	1840.92	534.10	3.14
4	2002.43	557.13	3.59
5	1521.87	453.25	3.36
6	2322.18	567.91	4.09
7	1243.78	553.21	2.25
8	2160.51	641.90	3.37
9	1552.32	509.11	3.05
10	1381.58	406.21	3.40
Average value ± standard deviation	1834.68 ± 383.76	547.21 ± 83.43	3.35 ± 0.48

By above TABLE 8 data, it is clear that knee joint in flexion, its quadriceps femoris muscle strength weight bearing ratios are in the range of [2.25,4.09] times, arms force deceases by comparing with standing position posture, while muscle torque increasing leading quadriceps femoris muscle strength increases, meanwhile muscle strength increasing can cause quadriceps femoris weight bearing increases that let it prone to get tired.

Patellar ligament is the extension of quadriceps femoris tendon, quadriceps femoris extension would also accompany by patellar ligament extension, while quadriceps femoris extension will also accompany with patellar ligament extension, quadriceps muscle strength is basically also loaded by patellar ligament, so strengthen quadriceps femoris muscle strength and patellar ligament tractive tension is effective way to prevent injury.

CONCLUSION

The paper firstly introduces body postures status when aerobics athletes take training to provide space analysis image base for researching its motion process knee joint force analysis; establishes two rigid bodies two freedom degrees dynamical model to provide theoretical basis for motion process knee joint moment analysis; after that, the paper through applying table form, it more clear presents two aerobics athletes existing differences, by comparing,we can get that two aerobics athletes differences are relative obvious, so for No.1 aerobics athlete, he should control shoulder joint in 65^0 that is suitable, and in consumed time, it summarizes with difficulties increasing, two aerobics athletes differences will be more obvious, and meanwhile it reflects No.1 aerobics athlete ability is relative prominent, by elbow joint aspect comparing, we find that No.1 aerobics athlete ability is stronger than No. 2 aerobics athlete, so it proves No.1 aerobics athlete comprehensive strength is stronger. Finally by researching aerobics athletes body right knee minimum joint angle, it gets habitual posture and right knee minimum joint angle instant posture such two postures, when joint angle gets smaller, muscle strength moment will be bigger, and gravity moment will be bigger, and muscle strength moment will accordingly increase.

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