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The Test Report on the Impacts of Subject Socks with the Application of Celliant® Technical Fibers on Transcutaneous Oxygen Pressure on a Man's Foot

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应用 Celliant®技术纤维的受试袜对人体足部经皮氧分压影响试验报告

The Test Report on the Impacts of Subject Socks with the Application of Celliant® Technical Fibers on Transcutaneous Oxygen Pressure on a Man's Foot

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一． 实验目的

1. The Purpose of the Test

通过对青岛新永国际贸易有限公司提供的应用 Celliant®技术纤维生产的袜子穿着前后对人体足背处局部经皮氧分压影响进行随机、双盲、对照的临床研究，对其改善人体局部微循环作用进行初步研究。

To do the preliminary study of the effects of socks that use Celliant® technical fibers provided by Qingdao ReY.S International Co., Ltd. on local transcutaneous Oxygen Pressure on human the foot dorsum through the clinical research before and after the wearing of the socks in a randomized, double-blind, and controlled way and on improving human body's local microcirculation.

二． 实验材料

2. Materials of the Test

应用 Celliant®技术纤维的袜子（简称，受试袜），对照袜（市售普通，无保健功能袜），医用胶带等。

Socks with the application of Celliant® technical fibers (for short: subjects socks), control socks (regular socks sold in the market with no health care function), medical tapes, etc.

三． 实验仪器和设备

3. Instruments and Equipment of the Test

单通道经皮氧分压／二氧化碳分压测定仪（PF5040 $TcpO_2/pCO_2$），帕瑞医学科技（北京）有限公司，型号：PeriFlux 5000.

Single-channel transcutaneous oxygen/ carbon dioxide partial pressure tester, (PF5040 $TcpO_2/pCO_2$), Perimed China LTD., Model: PeriFlux 5000.

四． 检测原理

4. Principle of the Detection

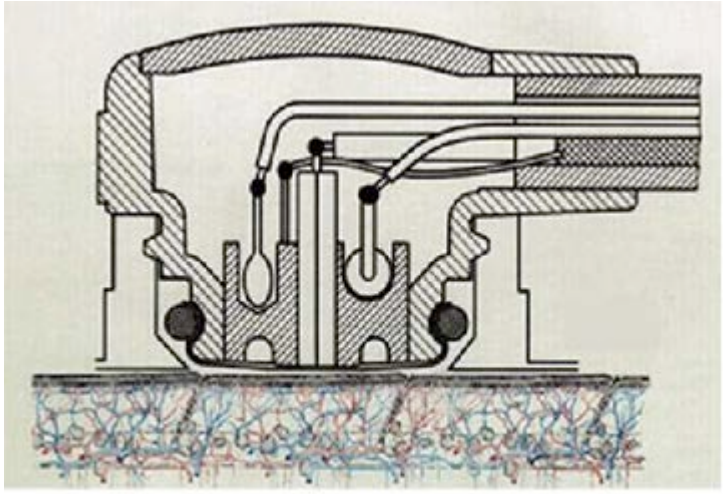

图1.经皮氧分压检测原理图

经皮氧分压/二氧化碳分压（ $TcpO_2/pCO_2$)）测定仪原理：本技术采用克拉克电极，通过预设电热调节器，将温度保持在 37-45□。在45□时，毛细血管血流动脉化。皮肤加热后，毛细血管扩张，氧离曲线右移，并允许氧气从皮肤扩散进入接触液。加热可以溶解死亡的上皮脂质层，改善气体透过皮肤的弥散性。已通过皮肤的氧气溶解在解除液中，然后降低到可测量的气流量。该气流量等于皮肤溢出的氧量，因此，测量接触液中的氧分压，相当于电极应用于皮肤 10-15 分钟后皮下组织中的氧分压。

The principle of the transcutaneous oxygen/carbon dioxide partial pressure（ $TcpO_2/pCO_2$)）tester: Through the preinstalled electric regulator, this technology uses Clark electrode to control the temperature at the 37 to 45□. At 45□, the blood flow of the capillary is arterialized. When the skin temperature rises, capillary expands and the oxygen dissociation curve moves towards the right side and the spread of oxygen from the skin into the contact liquid begins. Heating can dissolve the dead skins of epithelial lipid layer, and improve the dispersing of gas into skin. The passed oxygen dissolves into the contact liquid and then decreases the amount of measurable gas. The amount of the decreased gas equals the amount of oxygen that passes through the skin. Therefore, to test the oxygen partial pressure in contact liquid is to measure the oxygen partial pressure in subcutaneous tissue after using the Clark electrode to heat skin for ten to fifteen minutes.

测量传感器中加热部件将对传感器下的皮肤进行加热，从而使组织中毛细血管的血流量增加，其中运输的 O_2/pCO_2 将透过皮肤表面被传感器接收。具体示意见图 1。

The heating parts in the measuring sensors will heat the skin under the sensors,

which will increase the blood flow in capillary in the tissue and the passed O_2/pCO_2 through the skin will be absorbed by the sensors. Details are shown in Figure one.

五． 实验方法

5. Methods of the Test

（一）实验原则

(1) The testing principles

在参加本研究前，研究者将询问受试者的病史、健康状况等，如有需要，需进行体检和相关的实验室检查（如血常规、尿常规和血生化检查等），以确定受试者是否适合参加本研究。所有健康状态调查表和原始化验单将由检测机构保存。

Before the test, the researchers will ask participants about their medical history, heath conditions and so on. And if necessary, they are asked to do medical check-ups and other tests related to the research (such as blood routine, urine routine and blood biochemical inspection, etc.) to find out whether the participants are fit to participate in this research. All the investigation forms on health conditions and the original test reports will be kept by the research institution.

若受试者通过了相关的筛选，将在受试实验当天分别先后穿着对照袜和受试袜各一次，每次不超过 60 分钟，同时监测右侧足背处局部经皮氧分压的变化。

After the whole screening procedures, the participants will wear control socks and subjects socks once successively on the test day. The time for each is no more than 60 minutes and meanwhile the changes of local transcutaneous oxygen partial pressure at the right side of foot dorsum will be monitored.

1. 受试者入选标准

1. The criteria for qualified participants

男女各 50 人；

Fifty men and fifty women

年龄在 18-25 岁；

Ages are between eighteen and twenty-five

体重指数（BMI）在 19-24 之间，BMI＝体重（kg）/身高（m^2）；

Body Mass Index (BMI) is between nineteen and twenty-four. BMI = weight

(kg)/ height (m^2)

无心、肝、肾、消化道、神经系统、精神异常及代谢异常等病史；

No medical history of heart, liver, kidney, alimentary canal, nerve system, mental disorder, and metabolic disorder, etc.

无药物或其他物质过敏史；

No drug or other substance allergy history

体格检查示血压、心率、呼吸状况正常；

Normal blood pressure, heart rate and breathing condition shown by the physical examinations.

受试前一年内实验室检查：血常规、尿常规、肝肾功能基本正常（肌酐、尿素氮不超过正常上限，ALT、AST 在正常上限 1.5 倍以内）；

The tests in the year before the research include: blood test and urine test. And the liver and kidney function is basically normal (creatinine and urea nitrogen does not exceed the normal limit and ALT and AST are within 1.5 times more than the normal limit).

无不良习惯及嗜好，试验前两周及试验期间未服用其他药物及含有酒精和咖啡因的饮料；

No bad habits or hobbies. And two weeks before the test and during the test, there is no taking of any drugs or drinks that contain alcohol or caffeine;

自愿参加试验并签署知情同意书。

Voluntarily participate in the test and sign the informed consent form.

2. 受试者排除标准

2. **The criteria for unqualified participants**

主要脏器有器质性病变（如肝、肾、心血管疾病，代谢异常，神经系统疾病及其它慢性疾病）；

The main organs have organic diseases (such as liver, kidney, cardiovascular disease, metabolic disorder, nerve system disease, and other chronic disease);

常出现头痛、头晕者；

Regular headache or dizziness

收缩压＞130mmHg 和/或舒张压＞90mmHg 者；

Systolic pressure＞130mmHg and/or diastolic pressure＞90mmHg;

有任何物质或皮肤过敏史者；

Persons allergic to substances or have skin allergies;

有出血性疾病或明显的出血体质者；

Hemorrhagic disease or bleeding disorders;

药物滥用者；

Drug abuse;

嗜烟、酒者；

Smoking or drinking alcohol;

半年内有严重疾病史；

Serious disease history within half a year;

近三个月内参加过献血者；

Donating blood within the last three months;

近三个月内参加过其他药物临床试验者；

Participating in clinical tests of other drugs within three months;

三天前至试验期间服用过其他任何药物者；

Persons who take any other drugs three days before and during the test;

HBV、HCV 抗原阳性者；

Positive to antigen of HBV and HCV;

HIV 抗体阳性者；

Positive to antibody of HIV;

（二）具体实验过程

(2) Detailed Procedure of the Test

符合筛选标准的受试者知情同意书后在签订完，休息 15-20min 待状态稳定后，进行体温、血压及心率的测量，并记录。

After the qualified participants have signed the consent form, they will rest for a period of 15 to 20 minutes until they are calm. Their temperature, blood pressure and heart rate will be tested and the test results will be recorded.

双盲情况下，受试者先后穿着对照袜和受试袜，进行右侧足背部局部经皮氧分压的监测各 45 分钟，两双袜子之间的实验检测间隔 15 分钟。对照袜监测结束后进行体温、血压及心率的再次检测，并记录。

On the double-blind test, the participants will wear control socks and subjects socks successively. The monitoring time for the local transcutaneous oxygen partial pressure at the right side of the foot dorsum is 45 minutes for each. The time between the monitoring of two kinds of socks should be 15 minutes. After the monitoring of control socks, the temperature, blood pressure, and heart rate of participants should be measured and recorded.

对照袜及受试袜监测完毕后，受试者休息 15 分钟后，进行最后一次体温、血压及心率的检测，并记录。

After the ending of the monitoring of the control socks and subjects socks, participants will rest 15 minutes and then their temperature, blood pressure and heart rate will be measured and recorded again.

（三）数据处理方法

(3) Data processing methods

受试者分别穿着对照袜或受试袜后，进行足背处同一部位局部经皮氧分压动态监测，监测时间均为 45 分钟，两种袜子均选取稳定状态下的数据平均值（图 2）作为数据分析用局部经皮氧分压值（单位 mmHg），采用单因素方差分析对数据进行统计分析。

To monitor the dynamics of local transcutaneous oxygen partial pressure at the same spot of foot dorsum when the participants wear control socks and subjects socks respectively for 45 minutes, then the average of data under the stable state of both kinds of socks (Figure 2) will be used. Local transcutaneous oxygen partial pressure value (unit mmHg) will be used for analysis and data will be analyzed by using single factor variance analysis.

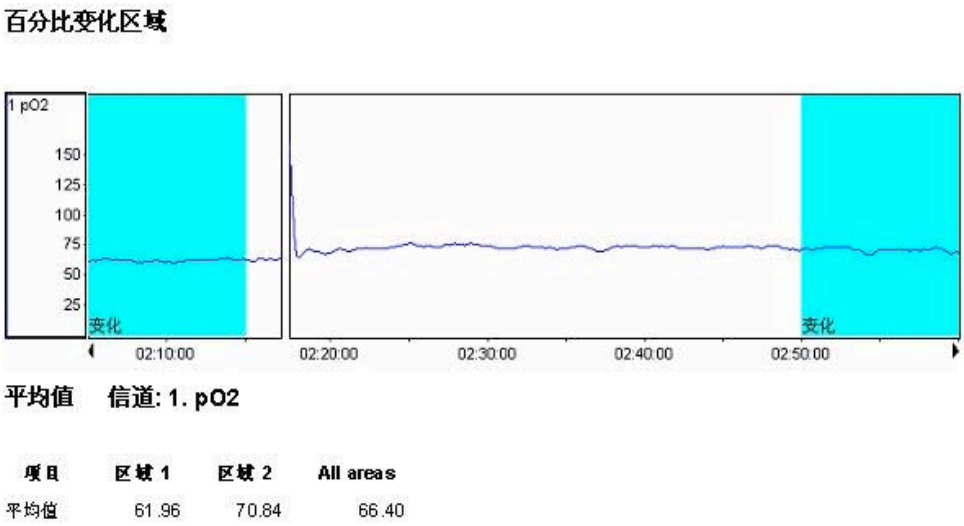

图 2 局部经皮氧分压动态数据采集示意图

Figure 2 The collecting of dynamic data of local transcutaneous oxygen partial pressure

区域 1 为对照袜稳态区域（图中时间点在前的有颜色标示区域），显示数值为此区域经皮氧分压动态数值的均值；区域 2 为受试袜稳态区域（图中时间点在后的另一段有颜色标示区域），显示数值为此区域经皮氧分压动态数值的均值。

Area one is the stable section of the control socks test (In the figure, the time before the stable section is marked with color.). The shown figure is the average of the dynamic values of local transcutaneous oxygen partial pressure of this area. Area two is the stable section of subjects socks test (In the figure, the time after the stable section is marked with color).The shown figure is the average of the dynamic values of local transcutaneous oxygen partial pressure of this area.

六． 实验结果

6. The Result of the Test

（一）受试袜及其对照袜对人体足背处局部经皮氧分压的影响

(1) The impacts of subjects socks and control socks on local transcutaneous oxygen partial pressure at foot dorsum

受试者穿着受试袜后，监测 45 分钟，足背处局部经皮氧分压为(73.28±14.93)mmHg；受试者穿着对照袜后，监测 45 分钟，足背处局部经皮氧分压为（62.60±15.69）mmHg（表 1）。方差齐性检验知：两种袜子对人体足背处局部经皮氧分压的方差齐性（表 2）。进一步方差分析结果显示，受试袜与对照袜

相比，受试袜对人体足背处局部经皮氧分压的影响具有极显著差异（$P<0.01$，表 3），可见受试袜与对照袜相比，在监测时间窗内，可更好的提高人体足背处经皮氧分压。

The participants wear subjects socks and then researchers monitor the local transcutaneous oxygen partial pressure at foot dorsum for 45 minutes. The result is (73.28±14.93)mmHg. The participants wear control socks and then researchers monitor the local transcutaneous oxygen partial pressure at foot dorsum for 45 minutes. The result is （62.60±15.69）mmHg (Table 1). Homogeneity of variance of local transcutaneous oxygen partial pressure at foot dorsum of two kinds of socks is shown (Table 2). Further variance analysis shows that compared with control socks, subjects socks' impacts on local transcutaneous oxygen partial pressure at foot dorsum has significant difference ($P<0.01$, Table 3). This demonstrates that compared with control socks, subjects socks within the monitoring period, can better improve the local transcutaneous oxygen partial pressure at foot dorsum.

表 1.两种袜子对人体足背处局部经皮氧分压的数据描述

Table 1 The data of the local transcutaneous oxygen partial pressure at foot dorsum of two kinds of socks

组别	N	均值	标准差	标准误	均值的 95%置信区间	
					下限	上限
对照袜	100	62.60	15.69	1.57	59.49	65.72
受试袜	100	73.28	14.93	1.49	70.32	76.24
总数	200	67.94	16.19	1.14	65.68	70.20

Groups	N	Average value	Standard deviation	Standard Error	95% confidence interval of the mean	
					lower limit	Upper limit
Control socks	100	62.60	15.69	1.57	59.49	65.72
Subjects socks	100	73.28	14.93	1.49	70.32	76.24
total	200	67.94	16.19	1.14	65.68	70.20

表 2 两种袜子对人体足背处局部经皮氧分压的方差齐性检验
Table 2 Homogeneity of variance of local transcutaneous oxygen partial pressure at foot dorsum of two kinds of socks

Levene 统计量	df1	df2	显著性
0.454	1	198	0.501

Levene statistics	df1	df2	Significance
0.454	1	198	0.501

表 3 两种袜子对人体足背处局部经皮氧分压的单因素方差分析
Table 3 Single factor variance analysis of local transcutaneous oxygen partial pressure at foot dorsum of two kinds of socks

	平方和	df	均方	F	显著性
组间	5697.568	1	5697.568	24.284	0.000
组内	46455.626	198	234.624		
总数	52153.194	199			

	Sum of squares	df	Mean square	F	Significance
Among groups	5697.568	1	5697.568	24.284	0.000
Within groups	46455.626	198	234.624		
Total	52153.194	199			

（二）受试袜对于人体足背处局部经皮氧分压的影响是否存在性别差异的分析

(2) Whether there is gender difference of subjects socks' local transcutaneous oxygen partial pressure at foot dorsum

1.受试袜及对照袜对男性足背处局部经皮氧分压的影响

1. The impacts of two kinds of socks' local transcutaneous oxygen partial pressure at men's foot dorsum

表 4 数据显示，男性受试者穿着受试袜后，监测 45 分钟，足背处局部经皮

氧分压为 (72.06±15.73)mmHg；受试者穿着对照袜后，监测 45 分钟，足背处局部经皮氧分压为（61.65±16.65）mmHg。方差齐性检验知：两种袜子对男性足背处局部经皮氧分压的方差齐性（表 5）。进一步方差分析结果显示，受试袜与对照袜相比，其对于男性足背处局部经皮氧分压的影响具有极显著差异（$P<0.01$，表 6），可见受试袜与对照袜相比，可更好的提高男性足背处经皮氧分压。

Statistics in Table 4 shows that after the male participants wear subjects socks and then researchers monitor the local transcutaneous oxygen partial pressure at foot dorsum for 45 minutes, the result is(72.06±15.73)mmHg. After the male participants wear control socks and then researchers monitor the local transcutaneous oxygen partial pressure at foot dorsum for 45 minutes, the result is (61.65±16.65)mmHg. Homogeneity of variance of local transcutaneous oxygen partial pressure at men's foot dorsum of two kinds of socks is shown (Table 5). Further variance analysis shows that compared with control socks, the subjects socks' impacts on local transcutaneous oxygen partial pressure at men's foot dorsum has significant difference ($P<0.01$, Table 6). It demonstrates that compared with control socks, subjects socks can better improve the local transcutaneous oxygen partial pressure at the men's foot dorsum.

表 4 两种袜子对男性足背处局部经皮氧分压影响的数据描述

Table 4 Statistics of the impacts of two kinds of socks' local transcutaneous oxygen partial pressure at men's foot dorsum

组别	N	均值	标准差	标准误	均值的 95% 置信区间	
					下限	上限
对照袜	50	61.65	16.65	2.35	56.92	66.38
受试袜	50	72.06	15.73	2.22	67.59	76.53
总数	100	66.85	16.94	1.69	63.49	70.22

Groups	N	Average value	Standard deviation	Standard Error	95% confidence interval of the mean

					lower limit	Upper limit
Control socks	50	61.65	16.65	2.35	56.92	66.38
Subject s socks	50	72.06	15.73	2.22	67.59	76.53
total	100	66.85	16.94	1.69	63.49	70.22

表 5 两种袜子对男性足背处局部经皮氧分压影响的方差齐性检验

Table 5 The homogeneity of variance test of the impacts of two kinds of socks' local transcutaneous oxygen partial pressure at men's foot dorsum

Levene 统计量	df1	df2	显著性
0.102	1	98	0.750

Levene statistics	df1	df2	**Significance**
0.102	1	98	0.750

表 6 两种袜子对男性足背处局部经皮氧分压的单因素方差分析

Table 6 single factor variance analysis of local transcutaneous oxygen partial pressure at men's foot dorsum of two kinds of socks

	平方和	df	**Mean square**	F	显著性
组间	2708.578	1	2708.578	10.326	0.002
组内	25705.992	98	262.306		
总数	28414.570	99			

	Sum of squares	df	Mean square	F	Significance
Among groups	2708.578	1	2708.578	10.326	0.002
Within groups	25705.992	98	262.306		

Total	28414.570	99

3. 受试袜及对照袜对女性足背处局部经皮氧分压的影响

3. The impacts of two kinds of socks' local transcutaneous oxygen partial pressure at women's foot dorsum

表 7 数据显示，女性受试者穿着受试袜后，监测 45 分钟，足背处局部经皮氧分压为 (74.50±14.17)mmHg；受试者穿着对照袜后，监测 45 分钟，足背处局部经皮氧分压为（63.56±14.79）mmHg。方差齐性检验知：两种袜子对女性足背处局部经皮氧分压的方差齐性（表 8）。进一步方差分析结果显示，受试袜与对照袜相比，其对于女性足背处局部经皮氧分压的影响具有极显著差异（$P<0.01$，表 9），可见受试袜与对照袜相比，也可更好的提高女性足背处经皮氧分压。

Statistics in Table 7 shows that after the female participants wear subjects socks and then researchers monitor the local transcutaneous oxygen partial pressure at foot dorsum for 45 minutes, the result is(74.50±14.17)mmHg. After the female participants wear control socks and then researchers monitor the local transcutaneous oxygen partial pressure at foot dorsum for 45 minutes, the result is (63.56±14.79)mmHg. Homogeneity of variance of local transcutaneous oxygen partial pressure at women's foot dorsum of two kinds of socks is shown (Table 8). Further variance analysis shows that compared with control socks, subjects socks' impacts on local transcutaneous oxygen partial pressure at women's foot dorsum has significant difference ($P<0.01$, Table 9). It demonstrates that compared with control socks, subjects socks can better improve the local transcutaneous oxygen partial pressure at women's foot dorsum.

表 7 两种袜子对女性足背处局部经皮氧分压影响的数据描述

Table 7 Statistics of the impacts of two kinds of socks' local transcutaneous oxygen partial pressure at women's foot dorsum

组别	N	均值	标准差	标准误	均值的 95% 置信区间

					下限	上限
对照袜	50	63.56	14.79	2.09	59.36	67.76
受试袜	50	74.50	14.14	2.00	70.48	78.52
总数	100	69.03	15.41	1.54	65.97	72.09

Groups	N	Average value	Standard deviation	Standard Error	95% confidence interval of the mean	
					lower limit	Upper limit
Among groups	50	63.56	14.79	2.09	59.36	67.76
Within groups	50	74.50	14.14	2.00	70.48	78.52
Total	100	69.03	15.41	1.54	65.97	72.09

表 8 两种袜子对女性足背处局部经皮氧分压影响的方差齐性检验

Table 5 The homogeneity of variance test of the impacts of two kinds of socks' local transcutaneous oxygen partial pressure at women's foot dorsum

Levene 统计量	df1	df2	显著性
0.102	1	98	0.750

Levene statistics	df1	df2	Significance
0.102	1	98	0.750

表 9 两种袜子对女性足背处局部经皮氧分压的单因素方差分析

Table 6 Single factor variance analysis of local transcutaneous oxygen partial pressure at women's foot dorsum of two kinds of socks

	平方和	df	均方	F	显著性
组间	2992.528	1	2992.528	14.299	0.000

组内	20509.696	98	209.283		
总数	23502.223	99			

	Sum of squares	df	Mean square	F	Significance
Among groups	2992.528	1	2992.528	14.299	0.000
Within groups	20509.696	98	209.283		
Total	23502.223	99			

4. 两种袜子对男性及女性足背处局部经皮氧分压的影响

4. The impacts of two kinds of socks' local transcutaneous oxygen partial pressure at men's and women's foot dorsum

图 3 显示，虽然受试袜与对照袜相比，不论对于男性及女性，足背处局部经皮氧分压存在数值上的差异，但是男性和女性的数据统计并无显著性差异。提示受试袜对于人体的足背处局部经皮氧分压的影响，并无性别之间的差别。结果如图 4，受试袜对于男性及女性均可显著性提高其足背处局部经皮氧分压，但无性别差异。

Statistics in Figure 3 shows that although compared with control socks, there is difference of subjects socks' impacts on local transcutaneous oxygen partial pressure at men's or women's foot dorsum, however the difference between the impacts on men's and women's are not significant. It shows that there is no gender difference in the impacts of subjects socks' local transcutaneous oxygen partial pressure at men's or women's foot dorsum. As shown in Figure 4, subjects socks can significantly improve local transcutaneous oxygen partial pressure at both men's and women's foot dorsum, and there is no gender difference.

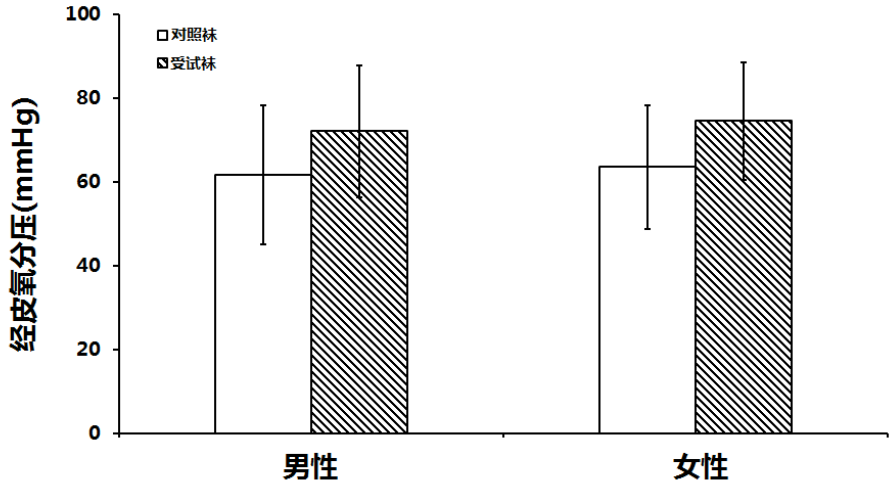

图 3 两种袜子对男性及女性足背处局部经皮氧分压差异性比较（n=50）

Figure 3 The comparison of difference between two kinds of socks' local transcutaneous oxygen partial pressure at men's and women's foot dorsum （n=50）

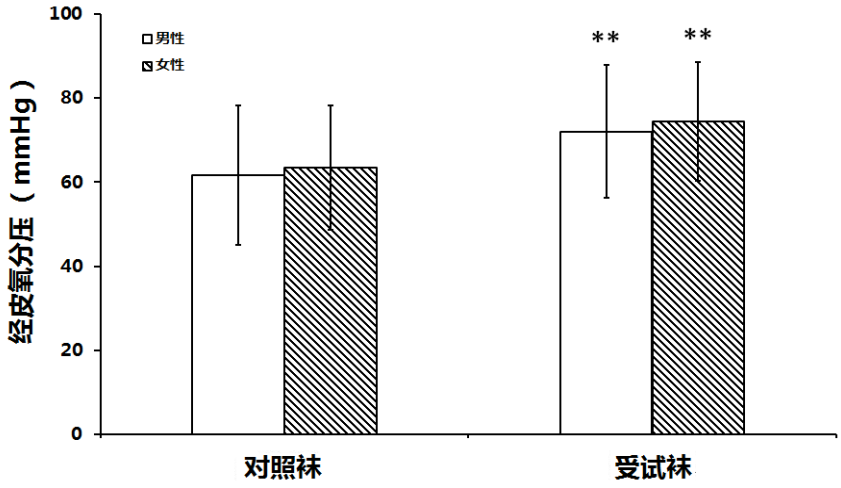

图 4 两种袜子对男性及女性足背处局部经皮氧分压的影响（n=50）

Figure 4 The impact of two kinds of socks' local transcutaneous oxygen partial pressure at men's and women's foot dorsum（n=50）

七． 讨论：

7. Discussion

经皮氧分压（$TcpO_2$）检测是一项能够反映毛细血管营养血流的技术。从 19

世纪 70 年代以来已经成为非侵袭性微循环血流的经典评价方法之一[1]，其能很好反映出下肢血管尤其踝以下皮肤微循环状态，进而反映周围动脉灌注情况，是一种操作简单，无创性的微血管病变检测的重要手段[2]。已有文献报道，相关的保健品如外用剂，涂抹剂，穿着材料等可通过微循环的改善作用来进行相关的保健评价[3]，而经皮氧分压可较好地反映局部微循环状态。本研究采用帕瑞医学 PeriFlux 5000 型单通道经皮氧分压／二氧化碳分压测定仪（PF5040 $TcpO_2/pCO_2$）对**青岛新永国际贸易有限公司**提供的应用 celliant®技术纤维的功能性受试袜穿着前后人体足部经皮氧分压进行检测，对其改善人体局部微循环作用进行初步探讨。

The measuring of transcutaneous oxygen partial pressure （$TcpO_2$）is a technology to reflect capillary's blood flow. Since the1870s, it has become one of classic methods to evaluate noninvasive blood microcirculation. It can well reflect the microcirculation state of lower limb blood vessel especially that of the skin beneath the ankle, which further reflects the peripheral artery perfusion situation. It is an important method that is easy to operate and has no invasive diagnosis at detecting capillaries. And there are documents which show that relative health-care products like topical agent, daub agent, dress materials and others can fulfill their function by improving micro circulation and transcutaneous oxygen partial pressure can relatively well reflect the local microcirculation state. This research uses a single-channel transcutaneous oxygen/carbon dioxide partial pressure tester, (PF5040 $TcpO_2/pCO_2$), model of PeriFlux 5000, generated by Perimed China Ltd to test the impacts on local transcutaneous oxygen partial pressure at the foot dorsum of subjects socks that adopts Celliant® technical fibers provided by **Qingdao ReY.S International Co.** before and after wearing them. The purpose of the preliminary research of Celliant® socks' is to improve the human body's local microcirculation.

微循环是指微动脉和微静脉之间的血液循环，是细胞供氧和排除废物的唯一通道[4]，是循环系统中最基本的结构和功能单位。人体单纯靠心脏的收缩力量不能将血液直接灌注到人体各器官的组织细胞，必需靠微循环部分的毛细血管不与心脏跳动同步的自律运动将血液进行第二次调节及第二次灌注，所以在医学上

把微循环比喻为人体的第二心脏[5]。

Microcirculation refers to the blood circulation between the arterioles and micro vein. It is the only channel[4] through which cells provide oxygen and eliminates waste and is the basic structural and functional unit in the microcirculation system. Only by cardiac contraction, the human body can't directly pour blood into cells of all organs of the body. It has to rely on the asynchronous (with the heart beat) self- discipline movement of capillaries of microcirculation part to adjust or pour the blood into organs for the second time. Therefore, in the medicine field, microcirculation is compared to the second heart[5] of the human body.

随着运动负荷加大的过程，微循环流速变缓，代谢产物（乳酸、尿素氮、肌酸、破碎细胞残片等）滞留，渗透压上升[6]，局部水肿（如大强度训练导致的小腿围度增加、肢端水肿）。由于微循环与人体各个部位的不可分割性，在不同的器官中微循环以其最小单元保持着与各器官的一致性。当疲劳程度进一步增加时，微循环代谢的迟滞使代谢产物不能及时从体内排除，电解质发生紊乱[7]，滞留组织的毒素会影响到中枢器官心、脑、肺、肾以及运动神经系统，使之出现灵敏度下降、反应迟滞、体能下降等疲劳现象。人体在微循环功能状态失常的情况下进行运动，会加速机体运动性疲劳的形成，微循环结构遭到破坏，容易导致微循环状态失常，运动性疲劳形成运动损伤[8]。微循环本身运行不受心脏能量控制，不受心率影响，但它随时可以作用于人体的健康状态，轻则影响局部组织和器官健康，如缺氧引起的肢端紫绀。当内环境持续高温，渗透压升高，毛细血管通透性增高可以促进渗出，发生在心包会压迫心脏，喉头水肿会导致窒息，严重微循环障碍甚至可以发生休克、昏迷甚至死亡。

With the increase of exercise load, the velocity of microcirculation slows, metabolites (lactic acid, urea nitrogen, creatine, segments of cells and others) accumulate, osmotic pressure rises[6], and local edema appears (such as increase of crus's girth, and acra edema brought by intensive training). Because of the integrity of microcirculation and the organs of the body, microcirculation maintains its uniformity with organs in the form of its smallest units. When the degree of tiredness further increases, the slowing of microcirculation can't eliminate metabolic wastes out of the body in a timely manner, electrolyte disorder occurs[7], and the accumulated toxin will

negatively affect the central organs, heart, brain, lung, kidney and motor nerve system, which leads to decreased sensitivity, lagged response, declined physical strength and tiredness, etc. If the human body exercises under the situation of microcirculation's abnormal state, it will accelerate the body's tiredness, damage the microcirculation structure, easily cause the abnormal microcirculation state, and lead to exercise injuries[8]. Although microcirculation itself is under no influence of the heart's energy and heart rate, it can affect the body's heath anytime. To a lower degree of damage, it affects the health of local tissue and organs, like acra cyanosis due to the lack of oxygen. When the inner temperature remains high, osmotic pressure rises. And the increase of capillary's permeability can facilitate the seepage. If it occurs at the pericardial area, it will press the heart and laryngeal edema will lead to suffocation. And the serious microcirculation malfunction will even lead to shock, coma and even death.

通过随机、双盲、对照的临床实验研究表明，应用 celliant®技术纤维的功能性受试袜与对照袜相比，可显著性提高安静状态下人体足背处局部经皮氧分压，并且无男女性别的差异。这提示此受试袜可能促进人体足背处局部的微循环，进而对人体产生保健作用。与此同时，大量文献报道，微循环的改善有助于促进正常人体组织营养物质的供应和代谢产物的交换，有助于提高体能，恢复疲劳，强健身体[9]。这也提示应用 celliant®技术纤维的功能性受试袜有可能促进人体疲劳的恢复，但这一结论还需要进一步的实验加以验证。

After the research done in a randomized, double-blind, and controlled way, it shows that compared with control socks, subjects socks adopting Celliant® technical fibers can significantly improve local transcutaneous oxygen partial pressure at the foot dorsum in a stable state, and there is no gender difference. This shows that this kind of subjects socks may improve the local microcirculation at the foot dorsum and thus fulfill their health care function for the human bodies. Meanwhile, much literature shows that the improvement of microcirculation is helpful to promote the nutrient supply and the exchange of metabolic products of normal human bodies, improve physical strength, alleviate tiredness, and strengthen the body. And this also implies that functional subjects socks adopting Celliant® technical fibers may be helpful for

the recovery of the body from tiredness. However, this waits for further testing.

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附表 1：受试者穿着两种袜子足背处局部经皮氧分压数值。

Attached table 1 Statistics of two kinds of socks' local transcutaneous oxygen partial pressure at the foot dorsum

受试者	经皮氧分压（mmHg）	
	对照袜	保健袜
男 1	61.96	70.84
男 2	61.96	70.84
男 3	82.23	89.80
男 4	55.46	66.41
男 5	55.46	66.41
男 6	55.96	71.48
男 7	94.45	102.16
男 8	74.98	81.90
男 9	51.79	54.14
男 10	60.37	68.16
男 11	75.35	91.23
男 12	74.44	77.67
男 13	68.31	79.83
男 14	61.76	75.00
男 15	87.04	88.88
男 16	20.34	28.99
男 17	45.03	52.10
男 18	72.89	77.49
男 19	54.23	88.50
男 20	43.71	51.69
男 21	89.86	92.15

男 22	30.57	39.95
男 23	86.13	90.31
男 24	62.78	68.46
男 25	34.12	48.75
男 26	78.21	110.67
男 27	74.11	82.15
男 28	79.04	86.45
男 29	62.69	72.92
男 30	49.96	57.42
男 31	77.03	89.04
男 32	62.91	66.63
男 33	61.07	73.94
男 34	71.51	82.96
男 35	62.23	73.47
男 36	66.90	76.41
男 37	36.24	66.17
男 38	56.20	72.76
男 39	66.70	75.96
男 40	31.07	53.22
男 41	56.11	63.21
男 42	23.05	46.08
男 43	58.44	59.21
男 44	57.07	64.88
男 45	67.74	82.70
男 46	71.04	71.74
男 47	71.61	77.97
男 48	63.72	74.54
男 49	72.05	75.73
男 50	44.60	53.55
女 1	51.23	66.74
女 2	23.59	43.67
女 3	77.67	104.09
女 4	43.08	62.73
女 5	59.09	59.27
女 6	52.43	58.85
女 7	77.62	87.22
女 8	40.36	47.54
女 9	81.28	83.22
女 10	83.12	107.13
女 11	50.08	90.62
女 12	58.35	69.55
女 13	60.92	61.14
女 14	60.92	61.14
女 15	74.61	79.80

女 16	74.61	79.80
女 17	77.91	81.54
女 18	79.52	82.02
女 19	68.65	72.30
女 20	58.95	72.52
女 21	56.21	67.17
女 22	56.21	67.17
女 23	50.82	65.69
女 24	74.12	83.87
女 25	64.98	73.80
女 26	58.97	64.33
女 27	75.91	81.59
女 28	71.37	80.17
女 29	42.46	76.76
女 30	76.51	84.36
女 31	93.71	97.99
女 32	61.40	68.83
女 33	93.71	97.99
女 34	67.06	73.86
女 35	51.67	73.30
女 36	48.70	64.07
女 37	56.80	68.06
女 38	35.17	35.29
女 39	58.64	71.97
女 40	65.18	75.25
女 41	72.52	83.62
女 42	68.65	96.98
女 43	54.46	62.03
女 44	70.10	81.39
女 45	79.25	84.27
女 46	62.34	66.95
女 47	38.99	72.88
女 48	75.37	79.19
女 49	62.78	71.71
女 50	79.85	83.51

Participants	transcutaneous oxygen partial pressure（mmHg）	
	control socks	subjects socks/ health -care socks
Male 1	61.96	70.84
Male 2	61.96	70.84
Male 3	82.23	89.80

Male 4	55.46	66.41
Male 5	55.46	66.41
Male 6	55.96	71.48
Male 7	94.45	102.16
Male 8	74.98	81.90
Male 9	51.79	54.14
Male 10	60.37	68.16
Male 11	75.35	91.23
Male 12	74.44	77.67
Male 13	68.31	79.83
Male 14	61.76	75.00
Male 15	87.04	88.88
Male 16	20.34	28.99
Male 17	45.03	52.10
Male 18	72.89	77.49
Male 19	54.23	88.50
Male 20	43.71	51.69
Male 21	89.86	92.15
Male 22	30.57	39.95
Male 23	86.13	90.31
Male 24	62.78	68.46
Male 25	34.12	48.75
Male 26	78.21	110.67
male 27	74.11	82.15
Male 28	79.04	86.45
Male 29	62.69	72.92
Male 30	49.96	57.42
Male 31	77.03	89.04
Male 32	62.91	66.63
Male 33	61.07	73.94
Male 34	71.51	82.96
Male 35	62.23	73.47
Male 36	66.90	76.41
Male 37	36.24	66.17
Male 38	56.20	72.76
Male 39	66.70	75.96
Male 40	31.07	53.22
Male 41	56.11	63.21
Male 42	23.05	46.08
Male 43	58.44	59.21
Male 44	57.07	64.88
Male 45	67.74	82.70
Male 46	71.04	71.74
Male 47	71.61	77.97

Male 48	63.72	74.54
Male 49	72.05	75.73
Male 50	44.60	53.55
Female 1	51.23	66.74
Female 2	23.59	43.67
Female 3	77.67	104.09
Female 4	43.08	62.73
Female 5	59.09	59.27
Female 6	52.43	58.85
Female 7	77.62	87.22
Female 8	40.36	47.54
Female 9	81.28	83.22
Female 10	83.12	107.13
Female 11	50.08	90.62
Female 12	58.35	69.55
Female 13	60.92	61.14
Female 14	60.92	61.14
Female 15	74.61	79.80
Female 16	74.61	79.80
Female 17	77.91	81.54
Female 18	79.52	82.02
Female 19	68.65	72.30
Female 20	58.95	72.52
Female 21	56.21	67.17
Female 22	56.21	67.17
Female 23	50.82	65.69
Female 24	74.12	83.87
Female 25	64.98	73.80
Female 26	58.97	64.33
Female 27	75.91	81.59
Female 28	71.37	80.17
Female 29	42.46	76.76
Female 30	76.51	84.36
Female 31	93.71	97.99
Female 32	61.40	68.83
Female 33	93.71	97.99
Female 34	67.06	73.86
Female 35	51.67	73.30
Female 36	48.70	64.07
Female 37	56.80	68.06
Female 38	35.17	35.29
Female 39	58.64	71.97
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Female 42	68.65	96.98
Female 43	54.46	62.03
Female 44	70.10	81.39
Female 45	79.25	84.27
Female 46	62.34	66.95
Female 47	38.99	72.88
Female 48	75.37	79.19
Female 49	62.78	71.71
Female 50	79.85	83.51