doi: 10.13241/j.cnki.pmb.2015.16.029

慢性非特异性颈部不适飞行员与无症状飞行员之间头颈夹肌表面肌电特征的比较

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摘要 目的:通过对慢性非特异性颈部不适飞行员与无症状飞行员之间头颈夹肌表面肌电特征的比较,为慢性非特异性颈部不适飞行员的早期诊断提供参考依据。**方法:**用表面肌电仪测量 52 名慢性非特异性颈部不适飞行员与 11 名无症状飞行员双侧头颈夹肌的松弛状态、等长收缩以及异长收缩时的表面肌电特征,分析不同状态下双侧头颈夹肌疲劳性肌电指标 MFs、MPFs、ZCRs 以及平均肌电 AEMG 值,用统计学软件 SPSS 18.0 分析实验结果。**结果:**非特异性颈部不适飞行员与无症状飞行员双侧头颈夹肌在松弛状态时疲劳性肌电指标 MFs、MPFs、ZCRs 比较均无统计学差异($P>0.05$),其双侧头颈夹肌在等长收缩和异长收缩时间有统计学差异($P<0.05$)。头颈夹肌处于松弛状态时,两组间平均肌电 AEMG 比较无统计学差异($P>0.05$),而在肌肉等长收缩和异长收缩时,两组间比较有统计学差异($P<0.05$)。**结论:**慢性非特异性颈部不适飞行员与无症状飞行员之间头颈夹肌表面肌电相关指标存在统计学差异,慢性颈部不适的飞行员相比无症状飞行员更易出现头颈夹肌的疲劳以及头颈夹肌的功能下降。头颈夹肌表面肌电特征有助于早期诊断慢性非特异性颈部不适飞行员的肌肉功能状态的改变。

关键词:飞行员;非特异性颈部不适;表面肌电

中图分类号:R85 **文献标识码:**A **文章编号:**1673-6273(2015)16-3115-04

Comparison of sEMG of M. Splenius Capitis and Cervicis Muscle between Nonspecific Neck Pain Pilots and Pain-free Pilots

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ABSTRACT Objective: To compare the sEMG indexes between nonspecific neck pain pilots and pain-free pilot, and provide references for the early diagnosis of pilots with chronic nonspecific neck pain. **Methods:** The surface electromyography was respectively used to measure the M. splenius capitis and cervicis muscle in relaxation, isometric contraction, iso-isometric contraction condition of 52 nonspecific neck pain pilots and 11 pain-free pilots. The sEMG indexes, such as MFs, MPFs, ZCRs and AEMG, were analyzed by software SPSS 18.0. **Results:** There was no significant difference of sEMG indexes of M. splenius capitis and cervicis muscle between nonspecific neck pain pilots and pain-free pilots in relaxation condition ($P>0.05$). There were significant differences of sEMG indexes of M. splenius capitis and cervicis muscle between nonspecific neck pain pilots and pain-free pilots in isometric contraction and iso-isometric contraction condition($p<0\ 05$). **Conclusion:** There were significant differences in some sEMG indexes of M. splenius capitis and cervicis muscle between nonspecific neck pain pilots and pain-free pilots. The nonspecific neck pain pilots were more easily to feel fatigue and cause the declined function. The surface electromyography was helpful for the early diagnosis of nonspecific neck pain of pilots.

Key words: Pilots; Nonspecific neck pain; sEMG

Chinese Library Classification: R85 Document code: A

Article ID: 1673-6273(2015)16-3115-04

前言

飞行员的工作训练环境与常人相差很大,经常处于高载荷环境中,由于加速度的原因导致颈部负荷较大,常发生慢性颈部不适等症状,已经成为影响飞行员完成飞行任务的重要隐患之一。然而,慢性颈部不适患者的临床检测指标往往正常,骨骼结构正常,软组织评价指标尚欠缺。因此,早期发现、诊断和治疗飞行员疾患尚存在较大的困难。如何对患有慢性颈部不适的飞行员进行客观准确的健康鉴定,也成为保障一线战斗力需要攻克的难题之一。

表面肌电图是在体表通过特殊设备引导和记录活动时神经肌肉系统生物电信号的变化,计算机通过累加处理这些电信号转换为相关的数据指标,临床上常用于神经肌肉功能的评价[1-4]。目前,肌电信号的检测往往采用针电极刺入的方式,其优点是干扰小、易识别、定位好,最主要的缺点是检测方法有创,因

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(收稿日期:2014-11-24 接受日期:2014-12-18)

此其应用受到一定的限制[5-8]。表面肌电图因为无创而易被患者接受,在国外广泛用于运动医学、康复医学的功能评估与治疗。然而,目前尚无文献报道将表面肌电图早期用于排查飞行员的颈部不适,是否可以有效避免飞行任务中存在的相关隐患。本研究拟采用表面肌电技术对慢性非特异性颈部不适飞行员进行相关检查,探究表面肌电指标是否能够为慢性颈部不适飞行员进行客观准确的健康鉴定提供技术支持。

1 对象和方法

1.1 研究对象

随机选择 2013 年 6 月 -2014 年 4 月在第四军医大学就诊以及在空军临潼航空医学鉴定训练中心疗养的 52 名存在颈部不适症状的飞行员作为病例组,其中直升机飞行员 17 人,运输机飞行员 13 人,歼击机飞行员 22 人。纳入标准:颈部不适持续 3 个月以上,且排除有神经根刺激症状、无颈屈异常等。同时,随机选择同期疗养的无症状飞行人员 11 名作为对照组，其中直升机飞行员 4 人,运输机飞行员 2 人,歼击机飞行员 5 人。两组的年龄、体重、身高、皮下脂肪厚度和电阻比较均无统计学意义(P>0.05),具有可比性。

表 1 病例组和对照组的基本情况比较

Table 1 Comparison of the basic information between test group and control group

	人数 Number (n)	年龄 Age (Y)	体重 Weight (Kg)	身高 Height (cm)	皮下脂肪厚度 Thickness of subcutaneous fat (mm)	电阻 Resistance (KΩ)
病例组 (Test group)	52	42.1± 7.3	62.7± 5.8	169.3± 7.9	5.2± 1.2	4.3± 0.9
对照组 (Control group)	11	44.7± 3.5	63.5± 6.3	171.2± 4.5	4.9± 1.3	4.5± 0.5

1.2 测试方法

电极放置:受试者坐位,双手自然放于身体两侧,根据 C7 棘突选定 C5 棘突,旁开 1 cm 处放置测量电极片。参考电极放置于测量电极中点外侧 3 cm 处。

松弛状态:受试者俯卧位,头部置于检查床凹槽中,双手自然放于身体两侧,双腿伸直,颈部肌肉松弛状态。记录头颈夹肌的体表电位,每次持续 10 s,重复 5 次,为一组,记录体表电位相关指标,反复测试 5 组,每组至少间隔 5 min。

等长收缩:受试者取正常坐位,颈部直立,头颈夹肌等长收缩 5 次,每次持续 10 s,此为 1 组,记录体表电位相关指标,反复测试 5 组,每组至少间隔 5 min。

异长收缩:受试者取正常坐位,颈部俯屈至最大位持续 10 s 后仰屈至最大位并持续 10 s,再恢复正常直立位,重复 5 次,为一组,记录体表电位相关指标,反复测试 5 组,每组至少间隔 5 min。

测试中选择了下列相关指标进行评估,MFs (median frequency slope): 中位频率下降率;MPFs (mean power frequency slope):平均功率频率下降率;ZCRs(zero crossing rate):过零率下降频率;AEMG(average electromyography):平均肌电,L 与 R 分别代表左和右。

1.3 统计学分析

采用统计软件 SPSS 18.0 进行统计学分析，两组间计量资料的比较采用 t 检验,以 P<0.05 为差异具有统计学意义。

2 结果

松弛状态时,病例组和对照组双侧头颈夹肌 sEMG 信号相关指标比较均无统计学差异(P>0.05),见表 2。病例组与对照组头颈夹肌等长收缩时,双侧 sEMG 信号相关指标的数值均存在统计学差异(P<0.05),病例组均显著高于对照组,见表 3。双侧头颈夹肌异长收缩时 sEMG 信号相关指标均存在统计学差异(P<0.05),病例组均显著高于对照组,见表 4。

表 2 两组双侧头颈夹肌松弛状态时 sEMG 信号的相关指标比较

Table 2 Comparison of the sEMG indexes of M. splenius capitis and cervicis muscle in relaxation condition between two groups

	左侧中位频率下降率 LMFs (Left median frequency slope)	右侧中位频率下降率 RMFs (Right median frequency slope)	左侧平均功率频率下降率 LMPFs (Left mean power frequency slope)	右侧平均功率频率下降率 RMPFs (Right mean power frequency slope)	左侧过零率下降频率 LZCRs (Left zero crossing rate)	右侧过零率下降频率 RZCRs (Right zero crossing rate)
病例组 (Test group)	-1.26± 0.83	-1.33± 0.88	-1.68± 1.25	-1.56± 0.98	-5.02± 1.47	-3.99± 2.21
对照组 (Control group)	-1.35± 1.22	-1.48± 0.32	-1.70± 0.96	-1,79± 1.16	-4.28± 2.21	-3.88± 2.51
P	>0.05	>0.05	>0.05	>0.05	>0.05	>0.05

表 3 两组双侧头颈夹肌等长收缩时 sEMG 信号的相关指标比较

Table 3 Comparison of the sEMG indexes of M. splenius capitis and cervicis muscle in isometric contraction condition between two groups

	左侧中位频率下降率 LMFs (Left median frequency slope)	右侧中位频率下降率 RMFs (Right median frequency slope)	左侧平均功率频率下降率 LMPFs (Left mean power frequency slope)	右侧平均功率频率下降率 RMPFs (Right mean power frequency slope)	左侧过零率下降频率 LZCRs (Left zero crossing rate)	右侧过零率下降频率 RZCRs (Right zero crossing rate)
病例组 (Test group)	-2.96± 1.33	-2.83± 0.88	-3.68± 1.25	-3.49± 0.67	-8.35± 1.56	-6.93± 1.27
对照组 (Control group)	-2.01± 0.37	-1.98± 1.32	-2.82± 0.96	-2,79± 1.26	-6.92± 1.79	-5.98± 1.31
P	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

表 4 两组双侧头颈夹肌异长收缩时 sEMG 信号的相关指标比较

Table 4 Comparison of the sEMG indexes of M. splenius capitis and cervicis muscle in iso-isometric contraction between two groups

	左侧中位频率下降率 LMFs (Left median frequency slope)	右侧中位频率下降率 RMFs (Right median frequency slope)	左侧平均功率频率下降率 LMPFs (Left mean power frequency slope)	右侧平均功率频率下降率 RMPFs (Right mean power frequency slope)	左侧过零率下降频率 LZCRs (Left zero crossing rate)	右侧过零率下降频率 RZCRs (Right zero crossing rate)
病例组 (test group)	-7.25± 4.81	-6.86± 3.14	-9.01± 4.37	-7.98± 4,11	-10,15± 4.20	-9.31± 3.29
对照组 (control group)	-4.17± 3.26	-3.18± 2.89	-4.79± 2.13	-4.02± 4.28	-7.32± 3.69	-6.08± 4.82
P	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

表 5 为颈部不同运动状态时的体表平均肌电。AEMG 代表头颈夹肌在测试时间内的平均肌电，AEMG-1 代表头颈夹肌松弛状态，AEMG-2 代表头颈夹肌等长收缩状态，AEMG-3 代表头颈夹肌异长收缩状态，L 和 R 分别代表左侧和右侧。结果显示：双侧头颈夹肌在松弛状态时，病例组和对照组的 AEMG 比较无统计学差异(P>0.05)；而双侧头颈夹肌在等长收缩和异长收缩时，两组的平均肌电均有统计学差异(P<0.05)，病例组均显著高于对照组。

表 5 两组双侧头颈夹肌不同状态时的体表平均肌电比较(μv)

Table 5 Comparison of the AEMG(average electromyography)of M. splenius capitis and cervicis muscle in different condition between two groups(μv)

	左侧平均肌电 LAEMG-1 (Left average electromyography-1)	右侧平均肌电 RAMEG-1 (Right average electromyography-1)	左侧平均肌电 LAEMG-2 (Left average electromyography-2)	右侧平均肌电 RAMEG-2 (Right average electromyography-2)	左侧平均肌电 LAEMG-3 (Left average electromyography-3)	右侧平均肌电 RAMEG-3 (Right average electromyography-3)
病例组 (Test group)	18.36± 7.20	16.11± 5.72	35.86± 16.31	32.58± 9.21	47.86± 13.51	50.02± 18.31
对照组 (Control group)	15.36± 7.33	17.06± 5.82	18.58± 7.29	19.31± 6.13	27.85± 8.99	35.73± 13.79
P	>0.05	>0.05	<0.05	<0.05	<0.05	<0.05

注：1.松弛状态；2.等长收缩；3.异长收缩。

Note: 1.the relaxation condition; 2.the isometric contraction condition; 3.the iso-isometric contraction condition.

3 讨论

表面肌电图(sEMG)是由肌肉兴奋时募集运动单位所产生的一个个动作电位序列在皮肤表面累加而成，是一种非平稳的微弱信号，是一个客观的动态指标，可敏感记录来自肌肉收缩功能状态的量化改变，目前被广泛应用于运动学、医学等领域，

多用来评估存在运动障碍患者的运动协调功能[9-12]。

有学者研究发现体力活动诱发肌肉疲劳过程，sEMG 信号相比正常情况具有更可靠的反映[13-15]，表明肌肉疲劳后的体表信号更能准确反映组间差异，提示头颈夹肌在经过等长收缩和异常收缩后的差异更能准确反映肌肉功能的差异。相关研究还发现 MPF 和 MF 在反映肌肉功能水平的差异方面具有良好的特异性和敏感性。不论是静态还是动态的情况下，随着肌肉疲劳的发生发展，测试结果都会出现肌电频谱左移的现象，即频谱的 MPF 和 MF 值均下降。因此，相关指标的斜率可以反映肌肉功能的变化率，MFs、MPFs、ZCRs 这些反映斜率的指标即可反映出局部肌肉的功能变化，负值表示肌肉已经出现疲劳[16-18]。有学者通过对肱二头肌等长收缩时表面肌电的研究发现，在肌肉等长收缩过程中，存在一个力量相对恒定的阶段，中位频率(MF)、平均功率频率(MPF)这两个指标可间接反映整个收缩过程中的体表肌电同步状况，中位频率下降率(MFs)、平均功率频率下降率(MPFs)可间接反映整个收缩过程中力量变化状况，也可反映不同运动单位之间等长收缩力量的差异[19]。本研究结果显示病例组和对照组双侧头颈夹肌在松弛状态时疲劳性肌电指标 MFs、MPFs、ZCRs 无统计学差异($P>0.05$)，而疲劳运动以后，无论是肌肉经过等长收缩还是异长收缩，病例组和对照组之间疲劳性肌电指标均存在明显差异($P<0.05$)。这些结果表明患有慢性颈部不适的飞行员头颈夹肌在无论等长收缩还是异长收缩后，表面肌电相关的疲劳性指标呈现负值，并且绝对值随着疲劳状况增大，较无症状者更易出现肌肉疲劳，导致肌肉功能下降。

本测试中，慢性颈部不适的飞行员相比无症状飞行员，头颈夹肌的平均体表肌电在经过等长收缩和异常收缩后相比松弛状态存在一定程度的升高，并有统计学差异($P<0.05$)。有国外学者在研究腰部表浅多裂肌和腹内斜肌时，也得到类似结论。肌肉收缩时，体表肌电活动会发生显著变化。研究坐位、松弛位以及腰部反复屈伸运动后得到腰部表浅多裂肌和腹内斜肌在松弛位体表肌电最低；保持坐位时，腰部表浅多裂肌和腹内斜肌在一定程度上处于等长收缩状态，体表肌电相比松弛位有明显升高；受试者在经过腰部屈伸运动后，即肌肉经过有力收缩后，体表肌电最高[20]。因此，体表平均肌电可以客观评价慢性颈部不适患者早期的头颈夹肌功能。

本研究中，数据变异程度比较大，该测试中 MFs、MPFs、ZCRs、AEMG 等指标均由软件测试计算所得，考虑数据差异大的原因可能有以下因素导致：首先，受试者在控制头颈夹肌的不同状态时，个人差异比较显著，肌肉收缩强度差异较大，即便是等长收缩状态，肌纤维依旧存在微小的长度变化；其次，表面肌电测试为敏感指标检测，为多信号累加而成，因此个人体表脂肪厚度、肌肉厚度等对测试也存在影响。

总之，本研究结果提示慢性颈部不适的飞行员相比无症状飞行员更易出现头颈夹肌的疲劳以及头颈夹肌的功能下降，这为患有慢性颈部不适飞行员的健康鉴定提供了技术支持。在下一步的研究中，我们还将采取或者寻找更有效的体表肌电检查方法，以克服数据变异大的缺点；寻找更高端的计算方法，更直接的规律，以更直观地对飞行员进行早期健康鉴定，避免飞行任务中的相关隐患。

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