

## What is sleep apnea?

My daughter has a friend called James. He's a young man, 22 years old, very healthy and fit. He plays football for the university team, and has recently been making a big effort to put on weight to improve his strength and power on the field. He came to dinner last week but wasn't his usual cheerful self.

'I hear you've had a cold,' I said to him.

'Yes,' he replied, 'and I've been so tired. I wake up tired in the morning, and I fall asleep all the time. I was watching television with my brother the other night and I fell asleep, but then he woke me up—he said I was snoring so loudly he couldn't hear the TV. And he said I made this awful noise, like a pig snorting.'

I looked at his neck, which has become so much thicker recently with all his weight training, and his tired, drooping eyes.

'That sounds like sleep apnea.' I said.

He looked startled. 'Me? What is it anyway?'

The general term for a sleep disorder with apneas is *sleep-disordered breathing* (SDB). When you have an apnea, air stops flowing to your lungs for ten seconds or longer. When you don't quite have an *apnea*, but the flow of air is halved for ten seconds or longer, it is called a *hypopnea*. The most common type of sleep-disordered breathing is *obstructive sleep apnea* (OSA). As the name suggests, this is sleep apnea caused by an obstruction.

You can develop an obstruction in your upper airway during sleep simply because your muscles relax, and collapse into your airway, or because the weight of your neck narrows the airway. The obstruction can be temporary—for instance, because of inflamed tonsils—or structural, because of the shape of your upper airway and jaw. It occurs when your upper airway closes but you still keep trying to breathe.

Both apneas and hypopneas cause *sleep arousals*—moments when you wake enough to start breathing again, but not enough to realise that your sleep has been interrupted. Some sleep arousals simply cause you to shift into a lighter stage of sleep. Some people can have as many as 40 or 50 of these sleep arousals every hour, and their sleep becomes very disrupted.

Of course this leaves them sleepy. It reduces their concentration and makes them more prone to have accidents. It also has an effect on how their entire body functions. Because apneas and hypopneas mean that air is not getting through to the lungs to provide oxygen throughout the body, blood oxygen levels can drop. >

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## From the Editor



This edition of Snooze Newz goes right back to basics to look at the different types of sleep apnea and their

treatment. We have two fascinating interviews with people who are using different devices to treat their very different types of sleep apnea. Phil Lovell, who uses a VPAP Adapt, shows us how a patient can work with their clinician to find the most effective treatment. Phil Gogell's OSA was detected during a screening program that ResMed is conducting with Pilbara Iron.

We've also spoken to a panel of experts who answered our questions with enthusiasm. Their responses showed us that major discoveries are still being made in the field of sleep-disordered breathing.

Our interviewees were Dr Peter Gay, Associate Professor of Medicine at the Mayo College of Medicine, Rochester; Dr Ian Wilcox, who is a Cardiologist in a group Academic Cardiology practice, a Consultant in Cardiology at Royal Prince Alfred Hospital and is a Clinical Associate Professor at the Department of Medicine, Sydney University supervising a Research Program on Sleep and Cardiovascular Disease; and Dr Helmut Teschler, Professor of Medicine and Head of the Department of Respiratory Medicine, High Dependency Unit, and Center of Sleep Medicine at the Ruhrlandklinik, Faculty of Medicine, University of Essen, Germany.

Thanks to all the people we interviewed for their generosity with their time and expertise.

If you would like to comment on any of the articles in Snooze Newz, please contact us at [clinicalnews@resmed.com.au](mailto:clinicalnews@resmed.com.au).

You can also find more information about ResMed on our website [www.resmed.com](http://www.resmed.com)

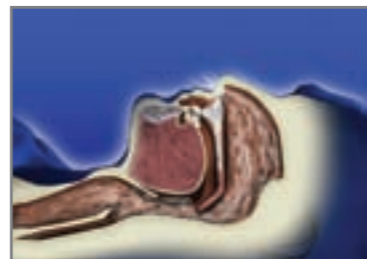
Rhonda Russo

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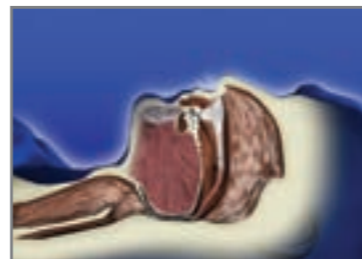
People with sleep apnea commonly have hypertension and decreased blood oxygen levels. Other symptoms of sleep apnea, that are easier to identify, are:

- Excessive sleepiness (use the Epworth Sleepiness Scale to evaluate sleepiness)
- Snoring (people with OSA usually snore but not always)
- Witnessed apneas or irregular breathing during sleep (gasping, long pauses, etc—a spouse or partner may notice these)
- Impaired concentration
- Impaired memory
- Morning headaches
- Sexual dysfunction.

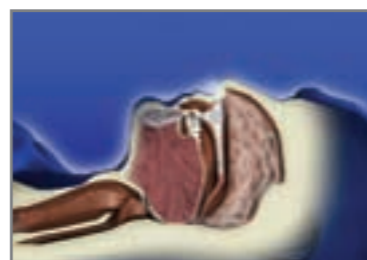
### The airway during sleep



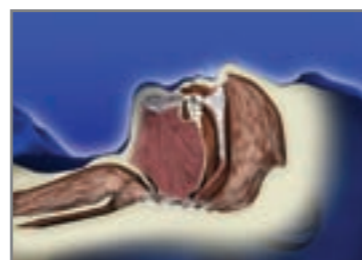
OPEN AIRWAY



PARTIALLY CLOSED



COLLAPSED



SNORE

To see a multimedia presentation about sleep-disordered breathing, showing how breathing is restricted, and the effects this has on your body, click on the link 'Understanding Sleep-Disordered Breathing' in the Patients section of the ResMed website [www.resmed.com](http://www.resmed.com).

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Do you want to look at the Epworth Sleepiness Scale and work out how sleepy you are? Go to the Patients section of the ResMed website [www.resmed.com](http://www.resmed.com). Under 'What is sleep apnea' you'll find the Epworth Sleepiness Scale in 'Test yourself'.

## Did they have sleep apnea?

We're all familiar with what doctors do; they listen to our symptoms and run tests, then give us a diagnosis and treatment. But what about doctors who diagnose a condition purely from what they can find in the historical or literary records? A number of researchers have shown that people who were recording 'quirks of nature' have actually left evidence of sleep apnea through the ages.

Dr ML Margolis has gathered support from a number of sources to show that the composer Johannes Brahms (1833-1897) suffered from obstructive sleep apnea (OSA). He quotes a friend of Brahms' who comments on his snoring, adding to this accounts of Brahms falling asleep during the day. Dr Margolis completes his deductions by pointing out that Brahms became progressively more obese, had a short, thick neck and a high alcohol intake—all danger signs for OSA.

*In later years, portly Brahms frequently snoozed in the afternoon in the cafes of Vienna, and his motionless flowing beard comprised a familiar sight for gawking tourists. A subsequent nap on the occasion of Brahms' first hearing of a promising young conductor by the name of Gustav Mahler in 1890 was interrupted by a 'queer snort'. While one is reluctant to ascribe too much significance to a single such description, the episode is reminiscent of the 'resuscitative snort' that frequently terminates an obstructive event in sleep apnea.<sup>1</sup>*

Brahms is not the only figure from the past to be diagnosed with sleep apnea. John Sotos has written about the possibility that President Taft (US president 1909-1913) had OSA<sup>2</sup> and points out that President Franklin D Roosevelt (US president 1933-1945) had several of the risk factors for OSA or central sleep apnea, including heart failure, snoring, obesity and excessive sleepiness.<sup>3</sup> Dr Chouard

and his colleagues considered whether Napoleon Bonaparte (1769-1821) had the same condition.<sup>4</sup>

Researchers have gone even further back in time, looking at descriptions of Dionysius of Heracleia (born approximately 360 BC) that reveal all the symptoms of sleep apnea, and reports by the Greek philosopher and historian Athenaeos (170-230 BC) that indicate that several members of the Ptolemys, the royal family that ruled Egypt from 305 to 30 BC "suffered from obesity and sleep disordered breathing."<sup>5</sup>

Literature also appears to observe sleep-disordered breathing. Charles Dickens' character 'Joe, the fat boy' in the *Pickwick Papers* (1836-37) spends his time eating and sleeping, is always sleepy and is difficult to wake from sleep. Dickens' portrait of Samuel Pickwick himself gives the classic symptoms of a man with sleep apnea (when intoxicated). Dickens' description is so well-observed that, "It was almost 150 years before a clinical description of sleep apnea that surpassed the description of Dickens was published."<sup>6</sup>

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# The different types of sleep apnea and who is likely to get them

“We know OSA is common, affecting about 20% of middle-aged men and 10% of middle-aged women.”

## Apneas in obstructive sleep apnea

People with obstructive sleep apnea (OSA) have apneas as a result of a physical obstruction in their upper airway. This is the most common type of sleep apnea. It occurs when your upper airway closes but you keep trying to breathe. One of the most common upper airway obstructions occurs because all of your muscles relax during sleep, so the tongue and other soft tissue falls to the back of the throat. OSA can also be caused by the weight of the neck muscles restricting breathing; the bigger the muscles, the more likely it is that they are going to affect the airway. This is why footballers can be prone to OSA. The shape of a person's upper airway and jaw can also influence the development of OSA. According to Dr Ian Wilcox:

*“We know OSA is common, affecting about 20% of middle-aged men and 10% of middle-aged women. It is the predominant type of sleep apnea in patients without heart failure or stroke.”*

## Apneas in central sleep apnea

Breathing is an automatic function, controlled by *the respiratory controller*. People with central sleep apnea (CSA) have apneas because their respiratory controller malfunctions and this interferes with the automatic regulation of their breathing. When you have CSA, your breathing stops but your airway is open. It's as if a short circuit prevents the brain from keeping the respiratory system functioning properly. This affects only 5–10% of people with sleep apnea.

Dr Wilcox describes four groups of people who experience central sleep apnea. The first group has occasional CSA, which is only detected if they have a sleep trial for suspected OSA. The second group is composed of people who have had a stroke. The third group is the group in which CSA is most common—people with severe heart failure. The fourth group is people who have temporary CSA when they are at high altitude.

*“Central sleep apnea occurs in four relatively common situations. Firstly, you may see a few central apneas during sleep studies in patients with predominant OSA. Secondly, traditional teaching has been that central sleep apnea occurs in people with stroke—in various patterns—but the overwhelming majority of people with stroke actually have OSA. Thirdly, and most commonly, it is the predominant breathing abnormality in heart failure, present in up to 70% of people with the more severe grades of heart failure. In this group it has traditionally been called Cheyne-Stokes breathing and you can have abnormal breathing during both sleep and wakefulness. Finally, central apneas occur commonly in otherwise healthy individuals at altitude, and may be associated with altitude sickness.”*

## Cheyne-Stokes respiration

Cheyne-Stokes respiration (CSR) is a type of central sleep apnea, caused by malfunctions in the respiratory controller rather than by obstruction of the airway. It is generally seen in people with the more severe grades of heart failure. However, it doesn't occur in every person with heart failure. As Dr Wilcox points out:

*“At no point in heart disease is the incidence of CSA/CSR ever 100%—20–30% of patients don't develop sleep-disordered breathing, no matter how bad the heart is.”*

We asked Dr Wilcox whether some people were more likely to develop central types of apnea (CSA and CSR) than others. He concluded that there are genetic influences and that gender also appears to affect a person's likelihood of developing CSA or CSR.

*“I think that there are individual factors that affect this ... I personally think that there are aspects of respiratory control that are inherited or innate, and which determine the proneness of patients to central apnea ... I think that we have seen a preponderance of sleep-disordered breathing of the central kind in men rather than women with heart failure. I don't think that's an accident—I think that one of the key factors is genetic differences and gender differences in ventilatory control, prior to the onset of heart failure. The effect of pre-existing OSA on development of CSA in the setting of new heart failure remains to be evaluated but you would have to think it would influence it one way or another.”*

## Apneas in complex sleep apnea

A person will be diagnosed with complex sleep apnea (CompSA) when they have both central **and** obstructive sleep apneas, and the levels of CSA increase during CPAP therapy.

Dr Helmut Teschler gives three possible reasons for central sleep apnea occurring during CPAP therapy: there is a reflex where the lungs respond to an unusually high flow of air and send a signal to the brain to shut down breathing; the CSA was there all the time, but had not been detected because the person had OSA—once the OSA was treated with CPAP, the person continued to have apneas and it became clear that they were CSA; the CPAP treatment is affecting the respiratory controller's functioning.

*“There are three possibilities for the central sleep apneas occurring under CPAP therapy. Firstly, they may be caused by the pressurization of the upper airway (Hering-Breuer Reflex). Secondly, it is a coexisting form of central sleep apnea, which might have been partially or totally disguised by the obstructive sleep apnea. In this case, the PAP might splint the upper airways and treat the obstructive elements quite well but unmask underlying periodic breathing abnormalities, for example due to diastolic dysfunction or due to side effects of different medications. Thirdly, the pressurization of the upper airway is causing a change in ventilatory control through interactions with chemosensitivity and respiratory drive.”*

“One of the most common upper airway obstructions occurs because all of your muscles relax during sleep, so the tongue and other soft tissue falls to the back of the throat.”

## Interview with Phil Lovell



Phil Lovell

Phil Lovell lives in an inner suburb of Sydney. He is an international Resource Manager for a banking software solution supplier. Since 2002, Phil has been receiving treatment from Dr Ian Wilcox. Over the past five years Phil hasn't just received treatment—he has worked with Dr Wilcox so that his treatment could change as his condition changed.

“ I use it every night ... I don't miss even one night—what would be the point? ”

“When I first went to see Dr Wilcox, the pressure on my CPAP was very high. He said I needed a CPAP with variable pressure. He told me that he wanted me to be responsible for what's going on, so I monitored my therapy regularly.” Phil would capture the results from his AutoSet Spirit™, view them in ResMed's AutoScan™ software, and regularly send them to Dr Wilcox.

This worked well for a number of years and Phil was feeling the benefits of sleeping better, having more energy and being more active. However, he was having the occasional arrhythmia (irregular heartbeat) and this became more frequent. “I was like a car that's not firing on all cylinders,” he explains. “My mind was saying 'let's move on' but my body was saying 'no'. It came to a head one day—I felt so ill and dizzy I had to go and see my local doctor, even though I had a scheduled appointment with Dr Wilcox the day after!”

An angiogram showed that there was no blockage in the heart. Phil's doctors recommended a cardioversion (a brief procedure where an electrical shock is delivered to the heart), and his heart rhythm normalized for a short time. After a second cardioversion Phil noticed on his AutoScan software that during the period when his heart rhythm was normal his apneas were improved, but on the night when the apneas returned, his heartbeat also became irregular again. He faxed his report off to Dr Wilcox.

Phil's results confirmed what he had observed: for the month after the cardioversion the AutoSet Spirit was recording a low level of apneas and hypopneas—the following week the level jumped dramatically, and was nearly four times as high.

Phil commenced a trial with the AutoSet CS2™, starting with a two-hour monitoring session in the ResMed North Ryde clinic.

“Since being on the AutoSet CS2 the apneas have gone—not even the odd one,” Phil notes with satisfaction.

The improvement in his condition means that Phil has been able to return to the exercise he likes best—cycling with his mates. Before, he would cycle for an hour and spend the next few hours sleeping. Now he does a regular 30 km cycle every Saturday morning, and sometimes rides on Sunday as well. Phil has noticed that his better health gives him more energy, and his family say he's now much more fun to be with. His work involves a lot of telephone contact with clients, and they've noticed the difference too. “They tell me I sound more relaxed now,” he says.

Phil purchased a VPAP Adapt SV™ in 2006. “I use it every night,” he says. “I don't miss even one night—what would be the point? I travel a bit and always take it with me. I went to India last year for a conference. I arrived at my hotel at about 2am to find the powerpoints in my room were too far away from the bed. The staff raced around looking for extension cords so I could go to sleep.”

Phil was willing to take control of his own condition and to work with his clinicians—this has led to the best treatment for his complex condition. He's enthusiastic about his therapy. “If I hadn't had this therapy the apneas would have put more pressure on my heart. Now I can sleep well, and my arrhythmia is also gone.”

Now he just needs a solar-powered VPAP Adapt SV so he can go trekking!

## Sleep moment: chronic pain, sleep and SDB

The relationship between sleep quality and pain is reciprocal—sleep quality affects pain and pain affects sleep quality.<sup>1</sup> Improving the quality of a person's sleep can reduce their sleepiness and pain, as well as improving their ability to function normally, and their mood.<sup>2</sup>

Chronic pain is 'a persistent pain for which the pain source cannot be treated'.<sup>3</sup> It is often associated with a past injury or with an ongoing medical condition. People with chronic pain have less refreshing sleep than people who are healthy.<sup>4</sup> This means that people being treated for chronic pain should have their sleep patterns monitored for any disturbances.

People with back pain, including spinal cord injury, are most likely to have sleep complaints related to chronic pain. Headaches, and the pain of conditions such as fibromyalgia and arthritis, can also result in significant sleep disturbances.<sup>5</sup>

In addition to suffering chronic pain, people with acute spinal injury and fibromyalgia are also highly likely to have sleep-disordered breathing (SDB). These groups of people have been extensively studied to determine whether treating their SDB can improve their pain management.

As in the general population, obstructive sleep apnea (OSA) in patients with spinal cord injuries is linked to weight, neck circumference and sleeping position, where lying on your back is almost always the worst position. These people are commonly unable to change position while sleeping, and muscle damage from their paralysis can make it difficult for them to breathe through a narrow airway.<sup>6</sup>

When people with spinal cord injury and excessive daytime sleepiness were treated with continuous positive airway pressure (CPAP), their daytime functioning, sleep patterns and oxygen saturation during sleep all improved.<sup>7</sup>

Fibromyalgia is a musculoskeletal disorder in which sufferers experience widespread pain, sore muscles, chronic fatigue and poor sleep. It runs in families and is more likely to affect women. The chronic pain felt by sufferers of fibromyalgia is made worse by poor sleep. Women with fibromyalgia are far more likely than the general population to have sleeping difficulties, including SDB.<sup>8</sup> When people with fibromyalgia have CPAP treatment, their sleep has been found to improve, and their ability to function normally during the day increases. The improved sleep from CPAP therapy can also lessen the constant pain associated with the condition.<sup>9</sup>

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### A seasonal tip

We've just passed the solstice, so it's mid-winter for some, mid-summer for others. If you're in the southern hemisphere, keep the room warm when you're using your flow generator, and keep the machine away from an open window—cold air being drawn through the flow generator into the mask can irritate the membranes of your nose, and cause rhinitis.

If you're living in a dry climate think about using humidification—very dry air can also cause rhinitis.

# How can sleep apnea be treated?

Just as there is more than one type of sleep apnea, naturally there is more than one type of treatment.

## CPAP

Continuous positive airway pressure (CPAP) machines are the most common flow generators as they treat obstructive sleep apnea (OSA), the most common form of sleep-disordered breathing (SDB).

When a person has OSA, there is a blockage in their airway, so the aim of the CPAP machine is to keep that airway open. The flow generator blows air through the tubing and mask into the nose and throat, where the slight pressure keeps the upper airway open. The CPAP machine works as a pneumatic splint—literally an air ‘splint’ to hold the throat open.

## APAP

APAP (automatic positive airway pressure) machines are also used in the treatment of OSA. Also known as ‘autotitration devices’, they represent a technological and therapeutic breakthrough for the treatment of OSA. These devices are constantly calculating the best pressure for the moment. They monitor for signs of apneas, hypopneas, flow limitation, and snoring and respond to the user’s changing needs by adjusting the pressure being delivered.

## VPAP

VPAP (variable positive airway pressure) machines are used when a person needs bilevel therapy. Bilevel therapy delivers two different levels of positive air pressure: a higher level of pressure for breathing in and a lower level of pressure for breathing out.

Bilevel devices can provide therapy for people with obstructive sleep apnea (OSA) if they have found CPAP therapy too difficult. They can also provide noninvasive positive pressure ventilation (NPPV) for people with respiratory disorders.

## ASV

The third form of positive airway pressure (PAP) machine is an adaptive servo-ventilation (ASV) device. It is used primarily to treat people with central sleep apnea / Cheyne-Stokes respiration (CSA/CSR) or complex sleep apnea—conditions often associated with heart failure.

We talked to cardiologist Dr Ian Wilcox about the development and use of ASV. He started by explaining that positive airway pressure had been effective in helping people with heart failure:

*“A whole series of studies that have been performed all over the world have looked at the value of positive airway pressure in heart failure, showing that it reduces afterload, functional mitral regurgitation, heart size and sympathetic nerve traffic.”*

However, using CPAP with these patients wasn’t able to address all their sleep-disordered breathing problems. As Dr Wilcox said, “... patients with heart failure and CSA/CSR are alternating between hyperventilation and apnea.” While CPAP could help with the apneas that occurred when the patient was trying to breathe in, it wasn’t helping with all the breathing problems they have. A new type of therapy was required.

Dr Peter Gay described this new type of therapy as a treatment that would adapt to the person’s stage of breathing: helping them to breathe in, then helping them to breathe out again.

*“In OSA the patient wakes with a gasp during the end of an apnea; in CSA the apnea is followed by a gradual increase in rapid breathing and the patient wakes up panting. The design of equipment for people with complex sleep apnea must be able to rapidly respond to both of these states—to the patient’s increased pressure needs during an apneic spell and the decreased pressure needs during a hyperpneic (rapid breathing) phase.”*

Dr Gay summed it up like this: “... we found that bilevel devices with a backup rate could work in these patients, and now we have the ASV devices which seem to be even more effective and are probably the device of choice now for CSR.”

And a final word from Dr Wilcox:

*“The concept of an intelligent breathing algorithm in the ASV, which anticipated what the breathing pattern would be, and responded to normalize it, is a remarkable innovation ... It is extraordinary that ASV treatment was developed in advance of widespread recognition of the diagnosis. Usually medical treatments follow recognition of the disease—they’re normally linked together—but therapies normally lag behind.”*



“ResMed has come a long way since then, fulfilling its customers’ needs for machines that are lighter, quieter and more portable.”

ResMed’s AutoSet CS2™ and VPAP Adapt SV™ are both adaptive servo-ventilation (ASV) devices. They meet the different needs that people with complex sleep apnea have at different times of the breathing cycle—increasing pressure during an apnea and decreasing pressure during a hyperpneic (rapid breathing) phase.

The VPAP Adapt can be used with standard ResMed modules, such as the H2i humidifier, masks and monitoring devices. These modules are nearly as important as the machine itself; humidification is extremely important for breathing comfort and a mask that fits well minimizes leak. This means that you’re more able to benefit from the therapy—when the machine is more comfortable, it’s easier to use.



## Then And Now...



### The ‘Vortex’

One of the earliest CPAP devices, the Vortex, developed in 1981, was ‘bigger than a breadbox’ at 240 mm long x 215 mm wide x 250 mm high (9.5” x 8.5” x 9.8”) and a weighty 6.75 kg (15 lbs).

### S8 series, released 2006

ResMed has come a long way since then, fulfilling its customers’ needs for machines that are lighter, quieter and more portable. The latest series, the S8™, measures 145 x 164 x 117 mm (5.7” x 6.5” x 4.6”) and weighs just 1.3 kg (2.9 lbs).

# Sleep apnea in the Pilbara

The Pilbara is a region of north-western Australia, with an area of over half a million square kilometres. Tourists come to the Pilbara to see the astonishing range of wildflowers between July and September or to see the magnificent Aboriginal rock engravings on the Burrup peninsula. ResMed went to the Pilbara in 2006-07 to conduct a pilot program with Pilbara Iron, screening its employees for sleep apnea.

Pilbara Iron employs nearly 4,000 people throughout its operations in Western Australia, finding, mining and processing iron ore. In 2005, Pilbara Iron produced over 140 million tonnes of iron ore. In an operation of this size, it is crucial that employees are working at their peak, both for their own safety, and so that production flows smoothly. When the medical staff at Pilbara Iron became aware that there were potential safety benefits in treating employees with sleep-disordered breathing, they were keen to investigate treatments. Two reports show the very positive benefits of treatment for a mine such as this: one report shows that treating SDB can lead to an eight-fold reduction in accidents and incidents, and the second demonstrates that when drivers are treated for their SDB, there is a 73% reduction in preventable driver accidents.

Twenty-seven volunteer employees were screened with an ApneaLink, and their results were assessed by the Pilbara Iron medical staff working with ResMed staff. One of the pieces of data that the ApneaLink records is the number of apneas and hypopneas that a person has: this figure is averaged out over the night to give an apnea / hypopnea index (AHI). The clinicians found that ten of the volunteers had a low AHI, seven were in the mild category, six were moderate and four had a severe AHI (an average of more than

20 apneas or hypopneas in an hour). People in the 'severe AHI' category are at greater risk of developing Type 2 diabetes, stroke, congestive heart failure and hypertension, so for those four volunteers, treatment started immediately.

One of the employees treated was Phil Gogel. He (and his partner!) had known about his snoring for some time but he had never had it treated. He's feeling the positive effects of treatment, and says that there is a double benefit: "This has provided great benefits for my health and most importantly my relationship with my partner, who has also been suffering until now."

The program was so successful that RioTinto, the owners of Pilbara Iron, are currently conducting a similar program in four of their other mines.



“ This has provided great benefits for my health and most importantly my relationship with my partner, who has also been suffering until now. ”

**Phil Gogel,**  
Pilbara Iron Employee

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## MASKERADE

The design of masks has come a long way from 1985 when 350 glue-on masks were made to be used with the earliest flow generators. Today, there is a wide range of masks, designed for maximum comfort—and the mask stays on thanks to sophisticated cushions, not glue!

The design of a mask has to meet two very different needs—it has to fit close to the face, so that air doesn't leak out, yet it has to be gentle and flexible, so that it can move as the sleeper's face and body move. Add in the complication of all the different types of faces in the world, and you start to wonder if we shouldn't return to the glue-on approach.

Despite these huge design challenges, ResMed has recently developed two masks to fit the vast majority of people: the Mirage Quattro™ full face mask (with four cushion sizes) fits over 95% of users, and the Mirage Liberty™ full face mask (with two cushion sizes and three nasal pillow sizes) fits over 90% of users.

The mask designs are based on anthropometry—studies of diverse human faces—as well as looking at how people use their masks. This includes looking at how people move in their sleep, as well as how less dexterous and elderly people can fit the mask themselves.

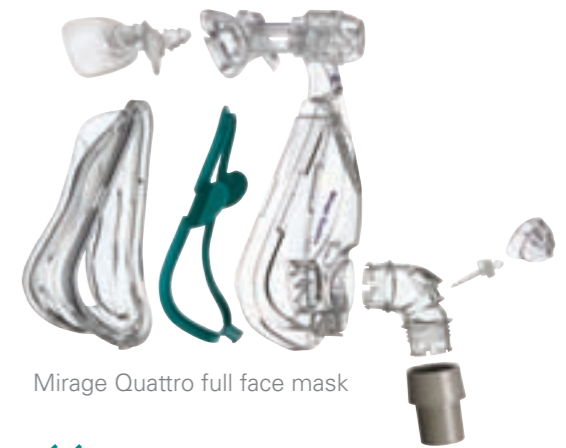
The masks meet the challenge of comfort and good seal by using a dual-wall cushion. This consists of two membranes that work together: the thin outer membrane seals lightly against the user's face and the thicker inner membrane provides support and stability.

There is a further detail of the inner membrane—its thickness varies at different points along the cushion. The thicker sections enhance seal while the thinner sections increase comfort.

The moving membrane on the Mirage Quattro full face mask also acts as a built-in solution for jaw drop. The membrane expands with jaw movement, so it remains sealed at the chin even if your mouth opens during sleep.

One of the other likely sources of leak—around the nose—is eliminated as the soft, moving membrane adapts to the shape of your nose, creating a seal and preventing leak into your eyes.

The same dual-wall technology is used in the Mirage Liberty's full face mask nasal pillows and mouth cushion. In the nasal pillows, the membrane that comes into contact with the nose is the softer thin outer membrane, which enhances comfort and reduces skin irritation. This fits to your nasal contours so that a seal is created, even for a broad range of users with different nasal structures.



Mirage Quattro full face mask

“ ResMed has recently developed two masks to fit the vast majority of people ”



Mirage Liberty full face mask

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## Mirage Liberty™

FULL FACE MASK

Full Face Freedom



### FREEDOM BY CHOICE FREEDOM BY DESIGN

#### The alternative to conventional full face masks

A sense of freedom inspires the design of this unobtrusive mask, giving users more choice in full face therapy. Incorporating dual-wall nasal pillows with trampoline action, Mirage Liberty is comfortable, stable and light ... all to encourage long-term compliance.



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sleep **v**antage™

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\* Currently sleepVantage is only available in Australia and the UK.

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